



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

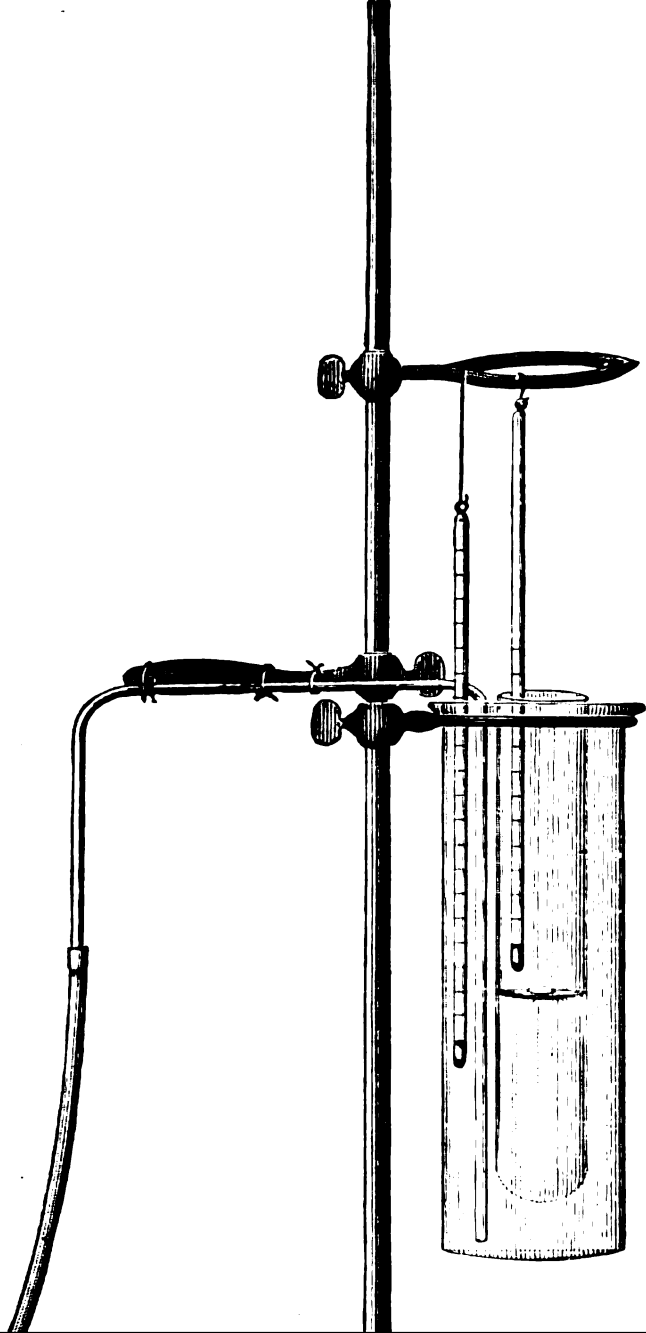
Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

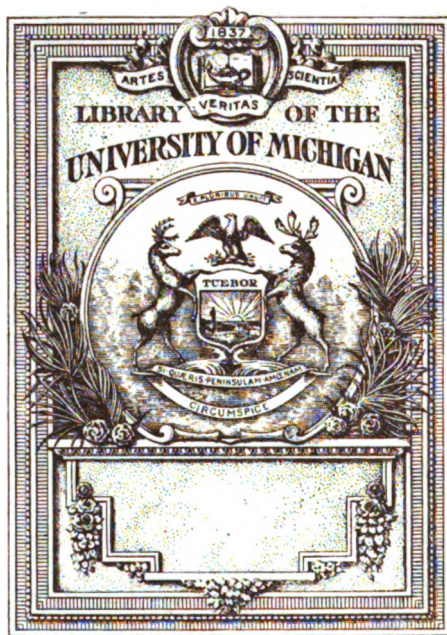
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



Bulletin - Bureau of Chemistry

United States. Bureau of Chemistry



S
585
.A5

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 14.

RECORD OF EXPERIMENTS

AT

FORT SCOTT, KANSAS,

IN



THE MANUFACTURE OF SUGAR

FROM

SORGHUM AND SUGAR-CANES,

IN

1886.

BY

H. W. WILEY,

CHEMIST.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1887.

11330—No. 14

70

3
U. S. DEPARTMENT OF AGRICULTURE.

U.S. Bureau
DIVISION OF CHEMISTRY.

BULLETIN

No. 14.

RECORD OF EXPERIMENTS
AT
FORT SCOTT, KANSAS,
IN
THE MANUFACTURE OF SUGAR
FROM
SORGHUM AND SUGAR-CANES,
IN
1886.
BY
H. W. WILEY,
CHEMIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., December 21, 1886.

SIR: I beg leave to submit herewith a report of the work done at Fort Scott during the present year under authority of Congress in "Experiments in the manufacture of sugar from sorghum and sugar-cane by the processes of carbonatation and saturation."

The conduct of this work you placed in my hands, and throughout the whole of it I have had your earnest support.

The results of the work are now presented for your inspection and approval.

Very respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR FROM SORGHUM.

The results of the experiments made at Ottawa last year gave encouragement to the friends of the sorghum sugar industry, and led to the undertaking of a new series of experiments at Fort Scott.

The Department of Agriculture entered into the following agreement with the Parkinson Sugar Company at Fort Scott:

WASHINGTON, D. C., *August 7, 1886.*

AGREEMENT BETWEEN THE COMMISSIONER OF AGRICULTURE AND THE PARKINSON SUGAR COMPANY OF FORT SCOTT, KANS.

The Commissioner of Agriculture agrees to erect at the works of the Parkinson Sugar Company of Fort Scott, Kana., one diffusion battery with all its appliances; three cane-cutters, one of which shall have a horizontal cutting disk, with appliances for feeding the cane to the same, and elevators for delivering the chips to the cells.

He further agrees to erect one carbonatation apparatus, to consist of a lime-kiln, carbonic-acid pump, four carbonatation tanks, and four filter-presses, with all their connections; also one sulphur apparatus, consisting of two sulphur furnaces, three saturation-tanks, three filter-presses, one air-pump, and all necessary connections.

He further agrees to prepare the whole of the above-mentioned machinery for practical work, and to provide all necessary labor and material for a thorough experimental trial of the same, and when this trial is finished to allow the Parkinson Sugar Company the free use of the apparatus for the rest of the manufacturing season of 1886, without any charge for rental to the Parkinson Company aforesaid.

It is expressly agreed and understood that all machinery furnished by the Department of Agriculture, and all fixtures and appliances therewith connected, shall remain the property of the Department, and the Commissioner reserves the right to make such disposition of all of it after the end of the present manufacturing season as may seem to him best suited to promote the public interest.

The Parkinson Sugar Company agree to furnish suitable buildings in which to erect this machinery, to supply steam for driving it and for use in the calorimeters of the battery, and to allow the Commissioner of Agriculture as much time as he may desire, not exceeding ten days from the commencement of the manufacturing season, for the purpose of making the experimental trials before mentioned; provided that during these experimental trials the Commissioner of Agriculture shall pay for all coal consumed for supplying the steam mentioned above, and for all limestone, coke, sulphur, filtering-cloths, and other materials used in the experiments.

The said company also agree to furnish a suitable room for the chemical laboratory to be erected by the Department and used by the Department chemists during the continuance of the manufacturing season.

It is further agreed on the part of the said Parkinson Company that during the period of the experiments mentioned the accredited representative of the Department at Fort Scott, namely, the chemist of the Department, or such other person as the

Commissioner may designate, shall have sole control and direction of the work, in so far as the extraction and purification of the sugar-juices are concerned.

Further, on the part of the Commissioner of Agriculture, it is agreed that during the entire manufacturing season he will supply the services of one superintendent, namely, Prof. M. Swenson, and one sugar-engineer, namely, Mr. G. L. Spencer, or some other persons of equal experience and ability, and also a competent corps of chemists; provided the company aforesaid give to said agents of the Department every facility for studying the processes employed, and supply them with full and accurate data of the amount of cane entering into manufacture, the quantities of sugar and sirup made, and all other information which will help the Commissioner to make a full and accurate report of the whole work; provided further, that after the experimental work above mentioned has been finished and during the time the said company operate the machinery for the purpose of manufacturing sugar and sirup for profit, the Department of Agriculture shall not be responsible for any other expenses than those which relate to the employment of the agents of the Department above mentioned.

NORMAN J. COLMAN,

Commissioner of Agriculture.

PARKINSON SUGAR COMPANY,

By C. F. DRAKE, *President.*

The Congress having made an appropriation of \$94,000 for the continuance of the experiments, the following contract was made between the Commissioner of Agriculture and The Pusey & Jones Manufacturing Company of Wilmington, Del., for the construction and erection of the necessary machinery.

WASHINGTON, D. C., *April 21, 1886.*

DEAR SIR: I desire to secure, for the experimental sugar station which the Department will establish in connection with the Parkinson Sugar Company, at Fort Scott, Kans., a diffusion battery. Will you kindly send me estimates of the cost of the battery, in conformity with the following general requirements?

- (1) The battery to be of a capacity to work 200 tons of cane in twenty-four hours at a mean rate.
- (2) The battery to consist of fourteen cells, arranged in a straight line, with valves, calorisors, and connections complete.
- (3) The cells to be cylindrical, and have a discharge-gate at the bottom of the area of the cross section of the cell.
- (4) The valves to be so arranged that the water can be introduced at top or bottom of each cell at the pleasure of the operator.
- (5) The joint of the discharge-gate to be made by hydraulic closure.
- (6) The last charge of water in each cell to be removed by compressed air.
- (7) Apparatus for the automatic charging of the cells with fresh chips.
- (8) Apparatus for removing the exhausted chips.
- (9) Calorisors to be furnished with thermometers, with face like steam-gauge.
- (10) Measuring tanks for withdrawing juice, with accurate float-gauge.
- (11) Two cane-cutters, with vertical disks, and forced feed, with cane-carriers and chip-elevators complete; these to be simply those already at Ottawa, with a modification of the forced feed, to prevent choking.
- (12) Air compressor and reservoir for discharging water from cell next to be emptied.

In the above apparatus all the valves, piping, shafting, pulleys, elevators, &c., which were used at Ottawa are to be incorporated in the new machinery where it is possible without disadvantage, and to be valued at their original cost price.

In your proposals, which I hereby ask for, please give all the details of the apparatus which must be guaranteed to work and give satisfaction to the Department.

Since the proper erection of this machinery is also essential to its success, I will ask you to submit a proposal to erect said machinery at Fort Scott and deliver it to the Department in proper working order on or before the 10th of August, 1886

Respectfully,

NORMAN J. COLMAN,
Commissioner.

WM. G. GIBBONS,
President, &c., Wilmington, Del.

WILMINGTON, DEL., May 8, 1886.

DEAR SIR: Replying to your favor of 21st ultimo, received three days ago, we offer to build the machinery therein specified, to say—

A diffusion battery, consisting of 14 cells, cylindrical in form, 44 inches in diameter, 7 feet 4 inches long, with door at bottom of full diameter of cell, and having counterbalance and hydraulic-joint packing; valves arranged so that the water can be introduced into cells at either top or bottom at pleasure.

An air-compressor and reservoir so arranged that the water in each cell can be removed by compressed air; apparatus for automatic charging of the cells with fresh chips and removing the exhausted chips to a comfortable distance from the battery.

Calorisators to be furnished with thermometers. Unfortunately those made in this country with face like steam-gauges are so slow of operation, that they would be useless. We are forced, then, to supply mercurial thermometers; will select the plainest dials to be had.

Proper measuring-tanks for withdrawing juice with floating gauge.

Alter the two cane-cutters now at Ottawa, Kans., so that the forced feed shall not choke, and supply cane carriers and chip-elevators. Price, \$14,125.

In this it is proposed to use such portions of the valves, pipes, and other things pertaining to the apparatus at Ottawa built by us as may be adaptable to the above.

We also propose to transport all of the above to Fort Scott, Kans., and erect at the works of the Parkinson Sugar Company and have in operation on or before the 10th day of August, 1886, for the further sum of \$2,500.

Soliciting the order, which shall have prompt dispatch, we are,

Yours, truly,

THE PUSEY & JONES COMPANY,
By WILLIAM G. GIBBONS,
President.

HON. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

WASHINGTON, D. C., July 26, 1886.

GENTLEMEN: I have received your communication of 25th instant in respect of the amount which you offer us in exchange for the machinery specified in my letter of 22d instant, and your offer is satisfactory to me. I therefore accept your proposition of 8th of May, last, viz:

"A diffusion battery consisting of fourteen cells, cylindrical in form, 44 inches diameter, 7 feet 4 inches long, with door at bottom of full diameter of cell, and having counterbalance and hydraulic joint packing; valves arranged so that the water can be introduced into the cells at either top or bottom at pleasure.

"An air-compressor and reservoir, so arranged that the water in each cell can be removed by compressed air; apparatus for automatic charging of the cells with fresh chips and removing the exhausted chips to a comfortable distance from the battery.

"Calorisators to be furnished with thermometers. Unfortunately those made in this

country, with face like steam gauges, are so slow of operation that they would be useless. We are forced, then, to supply mercurial thermometers. Will select the plainest dial to be had.

"Proper measuring tanks for withdrawing juice, with floating gauge.

"Alter the two cane-cutters now at Ottawa, Kans., so that the forced feed will not choke, and supply cane-carriers and chips elevators. Price, \$14,125.

"In this it is proposed to use such portions of the valves, pipes, and other things pertaining to the apparatus at Ottawa built by us as may be adaptable to the above.

"We also propose to transport all of the above to Fort Scott, Kans., and erect at the works of the Parkinson Sugar Company, and have in operation on or before the 10th day of August, 1886, for the further sum of \$2,500.

Replying further to your letter of 25th instant, I will say that the cane-cutters and battery now at the "Hermitage" plantation of Mr. D. F. Kenner, in Louisiana, will be delivered alongside the Cromwell Wharf, in New Orleans, before the 1st of September next, in accordance with your desires.

In further preparation of the work at Fort Scott, I desire you to submit to me your estimates of the cost of four filter presses and a sufficient number of carbonatation tanks, to be used in the experiments in the manufacture of sugar at Fort Scott during the coming campaign.

I desire this proposition to include the freight to Fort Scott; in other words, I ask you to deliver the apparatus just mentioned to the Department at Fort Scott, Kans., at the earliest possible moment.

Very respectfully,

NORMAN J. COLMAN,
Commissioner.

THE PUSEY & JONES COMPANY,
Wilmington, Del.

A contract was also made for a part of the apparatus for treating the diffusion juice with lime and carbonic acid in the following terms:

WILMINGTON, DEL., *August 3, 1886.*

DEAR SIR: We owe you an apology for so much time having been allowed to elapse since the receipt of your favor of 26th ultimo, and its reply. Illness in the family of the writer has prevented his attention, and hence the delay, which please excuse.

The diffusion machinery referred to in your letter is now being erected at Fort Scott, Kans., at the works of the Parkinson Sugar Company. Of the date of its starting we shall advise you later.

The four filter presses you inquire for will cost, delivered at Fort Scott, complete, all already for service, \$1,100 each. Four carbonatation tanks, each 6 feet 6 inches long, 4 feet 6 inches wide, and 6 feet 6 inches high at front, and 6 feet high at back, with receiving and discharge pipe and valves, gas-pipe, and distribution, copper coil heater, and vapor pipe, all complete, delivered at Fort Scott, Kans., \$350 each.

Soliciting your order, we are yours, truly,

THE PUSEY & JONES COMPANY,
By WM. G. GIBBONS, *President.*

HON. NORMAN J. COLMAN,
Commissioner of Agriculture, Washington, D. C.

The battery erected by the Pusey & Jones Company, consisted of 14 cells, arranged in single line, with calorimeters and apparatus for use of compressed air in discharging the water from each cell before dropping the exhausted chips. The working of the battery was entirely satisfactory.

Each cell had a capacity of 75 cubic feet, and would hold 1,900 pounds of sorghum chips, moderately packed. Each cell was constructed from the drawings obtained from the Fives-Lille Company, and the detailed description may be found in Bulletin No. 8.

The cutters used were those employed at Ottawa last year. The contractors made no attempt whatever to rebuild the forced feed attachment, and this failure was the cause of the chief delay we experienced after the apparatus was in regular use. With very sharp knives, and with cane fresh and green, they did reasonably good work, but after a frost had killed the leaves of the cane it was found almost impossible to make the cutters work. It often required half an hour to fill a single cell. When it is remembered that the rest of the apparatus could easily have worked a ton of chips each eight minutes, the disastrous effects of this delay can be appreciated.

From this cause great trouble was experienced in working the battery. When all the cells were in use each one was often under pressure three or four hours. The cane was unusually acid, and from this there followed a large inversion of sucrose in the battery. If, to avoid this, the temperature of diffusion was lowered, fermentation would set in. There was nothing left for us to do but to work a smaller number of cells. Often only six or seven cells were under pressure, and consequently the degree of extraction was far less perfect than it would have been otherwise.

The style of cutter used furnished a chip well suited to diffusion, but I am convinced that these cutters are more costly and require more power for operation than is necessary.

With a view of correcting these defects I purchased a beet-root cutter, formerly used by the Portland Beet Sugar Company, and had it rebuilt by the Colwell Iron Company of New York, for an experimental cane cutter.

This apparatus had a horizontal disk, and was so modified as to take a multiple feed, the cane being delivered to it through six hoppers inclined 40 degrees to the vertical. With perfectly clean canes this cutter gave promise of success, but with the sorghum-cane as it came from the field it proved a total failure.

This leads me to believe that the cutters used at Java and other places so successfully with sugar-cane would not serve the purpose of slicing sorghum for the battery. Any question of cleaning the canes before delivering them to the cutter must be negatived on the score of economy.

For the further study of the problem I tried the system of cane-slicing invented by Mr. H. A. Hughes, of Rio Grande, N. J.

The principle of this system consists in first cutting the canes into lengths of three or four inches by means of an ensilage-cutter, and after passing them through a cleaning apparatus deliver them to a shaving-machine constructed on the principle of a board-planer.

This latter part of the apparatus was kindly loaned to the Department by Mr. Hughes.

The canes were first cut by a Belle City ensilage-cutter into pieces about 2.25 inches in length. These pieces were run through a fanning-mill and nearly all the blades and sheaths were thus removed. The clean pieces of cane were next delivered to a slicer built on the principle of an ordinary board-planer. The cylinder was 6 inches in diameter and 30 inches in length, and carried two knives projecting one-eighth to one-sixteenth inch beyond the surface. This was driven at a high rate of speed, over 3,000 revolutions per minute. The canes were shredded rather than sliced by this process, so that the extraction of the sugar was rather a maceration than a diffusion.

Even with this small machine it was found possible to prepare nearly as much cane for the battery as with the three ponderous cutters described. It was found, however, that the ensilage-cutter was not strong enough to do the work, and hence this most promising system of cane-cutting, practiced successfully at Rio Grande, was discontinued. The experiment, however, led me to believe that the principle was the right one; especially is this so because it permits of the easy cleaning of the canes by first cutting them into small pieces. This seems to be the only practical way of accomplishing what is of prime necessity to diffusion, viz, the removal of all deleterious substances from the chips.

Having demonstrated the practicability of cleaning the cane in the manner already described, my attention was next directed to the consideration of the best method of cutting the short pieces of cane into chips suitable for diffusion. For this purpose I had constructed by the Fort Scott Foundry a centrifugal slicer. The theory of this apparatus was that the knives, being carried in a revolving frustum of a cone, and the short pieces of cane being fed from the inside of this cone, the chips, as soon as cut, would fly off by centrifugal force. A trial of this apparatus showed that the fiber of the cane would clog the knives and thus stop the work. The close of the season prevented any modification of the apparatus. I think the principle of the apparatus is promising enough to warrant further trial.

As a result of the experiments with cutters the following conclusions can be drawn:

(1) Whatever the form of the cutting-machine employed may be, it is necessary that the cane be cleaned. This cleaning should not consist of the removal of the blades alone, but also the sheaths.

(2) The slicing of the canes obliquely by means of a vertical cutting-machine with a forced feed is not an economical method of procedure.

(3) The use of a cutting-machine with a horizontal disk and multiple feed is impracticable for sorghum canes unless they are perfectly clean.

(4) The preliminary cutting of the canes into short lengths promises the easiest solution of the problem of cleaning the cane.

(5) The subsequent slicing of these sections by some form of apparatus is a mechanical problem which can be solved.

THE APPARATUS FOR DELIVERING THE CHIPS TO THE BATTERY AND REMOVING THEM THEREFROM.

The working of the chip elevators and the apparatus for removing the exhausted chips was exceedingly unsatisfactory.

The chips falling into the pit below the cutters were carried by a screw conveyor to a bucket elevator. Thence they were dropped onto a belt conveyor, which delivered them to the apparatus for blowing out the leaves, &c. The screw, the elevator, and the belt frequently became choked and occasioned a great deal of trouble and delay.

The apparatus for removing the exhausted chips gave still greater trouble.

In discharging a cell the whole contents, weighing a ton, were thrown at once on the conveyor. This load was too great, and many days' delay were experienced in making the alterations necessary even to moderate efficiency.

The elevator for taking the exhausted chips from this conveyor was a very complicated and inefficient piece of apparatus, and many tedious changes had to be made before it would do the necessary work. Finally its use was abandoned altogether. The lessons taught by these unfortunate delays show that the proper method for removing the exhausted chips from the battery is by means of a tramway and dump-cart, as practiced at Almeria and described in Bulletin No. 8. A great deal of apparatus and power will be saved by this method of disposing of the chips. The conveyor for filling the cells worked in marked contrast with the rest of the chip-handling machinery, and gave perfect satisfaction. This conveyor extended the entire length of the battery, and was placed directly above it. Over each cell was a door in the floor of the conveyor. When a cell was to be filled the door above it was opened and the chips fell through onto a funnel which directed them into the cell. The bottom of the conveyor at Fort Scott was too near the top of the cells. It should be not less than 6 feet above the top of the cells, so as to allow ample room for tamping the chips as they fall into the cell, thereby greatly increasing the capacity of the battery. I do not think a better contrivance could be devised for filling the cells of a line battery. I am still of the opinion, however, that the charging of a circular battery, as described in Bulletin No. 8, would be a more simple method. The disposition of the battery, however, is not a matter of vital importance.

I am further of the opinion that it will not be difficult for an ingenious mechanical engineer familiar with elevating apparatus to build the machinery which will elevate the cuttings to the battery without any difficulty. By the employment of the centrifugal cutter already described, which can be placed directly over the battery, the elevators will only have to carry the short pieces of cane, a very easy task.

MACHINERY FOR HANDLING THE CANE.

The apparatus for taking the cane from the carts and delivering it to the cutters was designed by Mr. W. L. Parkinson. The carts for bringing the cane from the fields are provided with a rack of peculiar construction. On this rack are placed ropes in such a manner that when the cart arrives at the unloading station the ropes can be brought together, inclosing the whole load of cane. By means of a power drum the entire load is drawn from the cart onto a weighing-truck running on a tramway.

As soon as the weighing is completed the truck is moved along the way until it comes opposite the cane-carrier. It is drawn from the truck by means of a power drum and is dragged down an inclined plane in large armfuls to the carrier. The carrier runs at right angles to the length of the cane and to the elevators which deliver the canes to the cutters. As the cane is carried along this feed-table the heads are cut off by a circular saw running at a high rate of speed. The heads which escape the saw are afterwards cut off by hand. The canes then pass to a point midway over the three elevators leading to the cutters. Thence by means of an ingenious contrivance it can be dropped into either carrier at will. The apparatus worked well, but aside from the removal of the tops I doubt whether so complicated a piece of machinery is necessary.

CARBONATATION APPARATUS.

This apparatus consists of a lime-kiln, washer for the gas, carbonic-acid pump, and carbonatation tanks.

LIME-KILN.

The lime-kiln was built by Mr. G. L. Spencer, with castings and plans from the Hallesche Maschinenfabrik. The pump was built by the same firm, but was purchased, as well as the castings just mentioned, from the Portland Beet Sugar Company. After the workmen learned how to conduct the operations at the kiln we had no trouble with its manipulation. It furnished an abundant supply of gas, and an amount of lime in large excess of the quantity required.

The limestone at first furnished contained a large quantity of cement and was unfit for use. In all, several days' delay was caused by this imperfection.

After reasonably good limestone was obtained all worked well. The analyses of the limestones employed will be found among the analytical data. The drawings and detailed description of the lime-kiln are found in Bulletin No. 8.

THE PUMP.

The pump was delivered to us in that state of imperfection which three months of very hard usage and six years of disuse produce.

Nevertheless, after a proper adjustment it worked with perfect satisfaction. In all not more than half a day's delay was caused by the adjustment of this apparatus.

THE CARBONATATION TANKS.

These tanks were built by the Pusey and Jones Company, according to the drawings and specifications in Bulletin No. 8, and gave perfect satisfaction. I can suggest no improvement in them unless it be the insertion of revolving paddles to keep down the foam.

THE FILTER-PRESSES.

These, four in number, and of thirty chambers each, were constructed by the Pusey and Jones Company, on the general plan of the Kroog filter-press, but with certain modifications suggested and patented by Mr. Swenson. Their work gave perfect satisfaction. The only fault discovered in them was the weakness of the plates, a great number of them breaking under the ordinary pressure.

THE SULPHUR APPARATUS.

This apparatus consists of an air-compressor, two sulphur furnaces, three sulphuring-tanks, and three Kroog's twin filter-presses. The whole apparatus was built by the Sangerhauser Maschinenfabrik, and its work gave entire satisfaction. The apparatus is described in detail in Bulletin No. 8.

The whole of the machinery, with the unimportant changes noted, was constructed according to the drawings and specifications printed in Bulletin No. 8. Their reproduction is not considered necessary here.

ANALYTICAL DATA.

The analyses of canes, chips, waste-waters, purified juices, &c., were made at the factory chiefly by Dr. C. A. Crampton, assisted by Mr. N. J. Fake. The limestones, masse-cuites, press-cakes, &c., were examined in the laboratory at Washington.

The analyses of the gases from the lime-kiln were made by Mr. G. L. Spencer.

Limestones, &c.

Serial No.	No.	Water.	Carbonic acid CO ₂ .	Insoluble and silica, SiO ₂ .	Fe ₂ O ₃ , Al ₂ O ₃ .	CaO.	MgO.	SO ₂ .	P ₂ O ₅ .	Sums.	Index to limestones.
		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>	
4581	1	.....	43.10	1.55	.97	54.70	.04	.03	.01	100.40	Selected from 150 cords of limestone on hand at the beginning of the season.
4582	2	.20	30.90	23.03	3.85	42.05	.07	.03	.03	100.16	Do.
4583	3	.05	41.84	3.10	1.40	53.55	.04	.02	.03	100.03	Do.
4584	4	.....	37.82	3.00	1.48	51.30	.....	.....	.....	98.60	Core of limestone burned in mill, doesn't burn.
4585	5	.....	40.07	5.92	.99	51.53	.....	.....	.....	98.51	Limestone brought in wagons from Fort Scott Lime Works.
4586	6	.....	37.55	10.01	1.07	49.26	.....	.....	.....	97.90	Duplicate sample.
4598	7	.....	26.06	2.50	1.56	63.84	.54	.87	.....	94.87	Selected from 150 cords of limestone on hand at the beginning of the season.
4599	8	.....	41.70	2.81	1.82	54.08	.27	.....	.....	100.68	Do.
4638	9	.....	41.70	1.68	1.42	55.40	.25	.....	.....	.....	Duplicate sample.
4651	10	.....	42.70	3.80	.93	52.02	.54	.....	.....	99.99	Limestone in use October 17, surface rock from a point 2 miles south of factory.
4652	11	.....	41.80	4.90	.72	52.26	.54	.....	.....	100.22	Limestone in use October 17 deeper in quarry.
4662	12	.10	40.00	5.40	3.14	57.83	.56	.....	.05	101.03	Do.
4663	13	.04	41.20	3.47	2.02	53.72	.44	.....	.10	100.99	Do.

	Burnt lime.	Slag.	Spent bone-black.
Serial number.....	4,587	4,588	4,600
Water	<i>Per cent.</i> 9.60	<i>Per cent.</i> 0.00	<i>Per cent.</i> 1.15
Carbonic acid CO ₂	0.00	Traces	1.13
Insol. and silica (SiO ₂)	4.36	39.30	.72
Fe ₂ O ₃ , Al ₂ O ₃	3.70	31.50	.....
CaO	81.40	38.60	.....
MgO	.09	Traces .....	.....
SO ₂	Undetermined ..	Traces .....	.....
P ₂ O ₅	Undetermined ..	.....	*35.80
Organic matter	Undetermined ..	.....	17.24
Bases .....	.....	.....	43.84
Sum	99.15	99.40	99.88

* Equivalent to Ca (PO₃)₂, 79.46.

† Contains N.

Mill juices before October 1.

No.	Ex- traction.	Sp. gr.	Solids.	Su- crose.	Glucose.	Date.	Index to mill juices.
	<i>P. ct.</i>		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>		
1.....	55.26	1.0773	18.7	13.25	.....	Aug. 30	Early amber cane from west field.
2.....	53.33	1.0669	16.3	11.46	1.88	Aug. 31	Early amber cane from east field.
3.....	57.14	1.0629	13.1	7.20	3.46	Aug. 31	Link's hybrid.
4.....	58.82	1.0574	14.1	7.50	4.35	Aug. 31	Early orange.
5.....	.....	1.0710	17.2	14.73	.....	Sept. 3	Early amber cane, juice extracted by hand.
28.....	60.60	1.0770	18.6	9.47	4.95	Sept. 15	Early amber cane from east field, cut two days
31.....	60.00	1.0788	19.0	7.04	7.80	Sept. 16	Early amber cane, cut three days.
37.....	51.60	1.0794	19.2	4.92	8.42	Sept. 17	Orange cane from wagons.
44.....	.....	1.0688	16.7	10.83	2.49	Sept. 18	Cane from carrier.
53.....	45.16	1.0832	20.0	13.54	2.97	Sept. 19	Do.
61.....	47.15	1.0734	17.8	11.48	3.58	Sept. 20	Amber cane from carrier.
70.....	68.68	1.0770	18.6	12.11	2.44	Sept. 21	Amber cane from carrier, cut yesterday.
71.....	56.10	1.0750	18.2	11.82	2.73	Sept. 21	Orange cane from carrier.
84.....	56.27	1.0818	19.5	11.02	4.20	Sept. 22	Amber cane from carrier, cut two days.
85.....	58.62	1.0888	21.2	14.70	2.77	Sept. 22	Amber cane from carrier, cut one day.
87.....	53.12	1.0848	20.3	3.60	11.36	Sept. 23	Amber cane from carrier, cut three days.
88.....	61.77	1.0718	17.4	9.49	5.33	Sept. 23	Cane from carrier.
89.....	58.44	1.0638	15.6	9.74	2.16	Sept. 23	Link's hybrid from field.
95.....	48.43	1.0776	18.7	13.53	2.41	Sept. 24	Cane from carrier.
97.....	56.56	1.0675	16.4	11.50	2.80	Sept. 24	Cane like preceding, except badly lodged.
102.....	59.37	1.0578	14.2	8.20	2.86	Sept. 25	Cane from carrier, (from lodged lot).
103.....	59.18	1.0678	16.5	10.17	3.47	Sept. 25	Orange cane, cut to-day.
1064.....	53.00	1.0728	17.6	12.40	1.90	Sept. 28	Cane from carrier.
112.....	51.51	1.0684	16.6	10.41	4.08	Sept. 29	Do.
119.....	56.10	1.0764	17.8	12.39	3.76	Sept. 30	Do.
Aver.	55.79	1.0723	17.56	10.49	4.01		
Coefficient purity....			50.73				

Mill juices after September 30.

No.	Ex- traction.	Sp. gr.	Solids.	Su- crose.	Glucose.	Date.	Index to mill juices.
	<i>P. ct.</i>		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>		
126	61.76	1.0634	15.5	8.37	4.95	Oct. 1	Cane from carrier, stripped.
131	.....	1.0842	20.2	14.50	1.77	Oct. 2	Cane from carrier.
138	54.54	1.0868	20.7	14.37	2.16	Oct. 3	Cane brought in cars from Hammond.
147	51.72	1.0680	16.6	10.50	2.60	Oct. 4	Amber cane from carrier.
150	51.85	1.0740	17.9	12.39	1.92	Oct. 4	Orange cane from carrier.
159	51.35	1.0710	17.2	10.65	3.27	Oct. 5	Cane from carrier.
169	56.60	1.0818	19.7	13.20	2.37	Oct. 5	Cane, amber, on car from Hammond.
170	57.70	1.0778	18.8	9.95	4.88	Oct. 5	Same, orange.
176	52.94	1.0801	19.3	2.11	.....	Oct. 7	Amber cane from Hammond.
177	53.85	1.0748	18.1	6.67	.....	Oct. 7	Same, orange.
180	55.55	1.0698	17.0	10.09	3.11	Oct. 7	Cane from car, same as two preceding, but better averaged samples taken from center of car, while the first samples were taken from the outside, amber.
181	53.12	1.0828	19.9	12.46	3.03	Oct. 7	Same, orange.
199	60.10	1.0678	16.5	9.10	4.26	Oct. 8	Orange cane from carrier (juice very red).
207	59.63	1.0640	15.6	9.07	3.84	Oct. 8	Cane from carrier, p. m.
213	58.06	1.0758	18.3	4.55	9.62	Oct. 9	Cane from carrier, a. m. (old cane).
222	58.82	1.0596	14.6	8.57	2.20	Oct. 9	Link's hybrid from field.
228	61.54	1.0556	13.7	7.72	3.38	Oct. 9	Orange from field.
224	60.00	1.0506	12.5	7.22	4.09	Oct. 9	Amber from field.
231	59.37	1.0766	18.5	7.02	7.74	Oct. 10	Cane from carrier, cut several days.
233	62.07	1.0764	18.5	8.66	3.04	Oct. 10	First fresh wagon-load lot in to-day.
241	57.90	1.0676	16.5	10.29	2.13	Oct. 11	Link's hybrid cane from Professor Swenson's, still green and not hurt by frost.
242	.....	1.0618	15.1	8.60	3.25	Oct. 11	Cane from carrier, freshly cut, a. m.
249	61.40	1.0632	15.5	8.86	2.98	Oct. 11	Cane from carrier, p. m.
258	62.16	1.0588	17.4	6.65	4.72	Oct. 12	Cane from carrier.
259	57.14	1.0718	17.4	8.54	5.04	Oct. 12	Cane on car from Hammond, orange.
260	58.83	1.0786	17.8	10.51	3.37	Oct. 12	Cane on car from Hammond, amber.
267	59.09	1.0692	14.5	8.83	3.10	Oct. 12	Cane, amber, lot from Hammond by Dr. Wiley and Professor Swenson.
268	61.54	1.0632	20.0	14.11	1.95	Oct. 12	Same, orange.
269	63.41	1.0672	18.4	9.53	4.56	Oct. 12	Same, orange, No. 2.
276	53.63	1.0636	21.5	5.71	11.41	Oct. 13	Cane for experimental run, orange, taken from same cars as yesterday's samples.
277	57.25	1.0646	20.3	12.05	4.19	Oct. 13	Same, amber.
279	59.46	1.0655	16.0	7.68	5.17	Oct. 13	Sample from other two cars from Hammond, orange.
280	62.07	1.0646	15.8	7.27	5.52	Oct. 13	Same, amber.
281	60.71	1.0654	16.0	10.09	2.23	Oct. 13	Orange cane from Professor Swenson's.
284	52.94	1.0618	15.1	4.15	7.84	Oct. 13	First mill juice from experimental run, taking sample every hour, orange.

Mill juices after September 30—Continued.

No.	Ex- traction.	Sp. gr.	Solids.	Su- crose.	Glu- cose.	Date.	Index to mill juices.
	<i>P. ct.</i>		<i>P. ct.</i>	<i>P. ct.</i>	<i>P. ct.</i>		
285	62.50	1.0608	14.9	4.84	7.25	Oct. 13	Same, amber, taken at same time as above.
287	.....	1.0621	15.2	5.83	6.07	Oct. 13	Second sample, orange.
288	50.00	1.0626	15.3	9.51	2.44	Oct. 13	Second sample, Link's hybrid, from Swenson's.
290	60.00	1.0678	16.5	9.77	3.75	Oct. 13	Third sample, orange, from Hammond.
294	56.52	1.0684	16.6	8.51	4.12	Oct. 14	Cane from carrier, amber.
295	62.86	1.0628	15.4	7.88	4.38	Oct. 14	Cane from carrier, orange.
310	.....	1.0580	14.3	7.45	4.50	Oct. 15	"Denton" cane, analyzed for Mr. Parkinson.
311	.....	1.0400	10.0	3.66	3.31	Oct. 15	Green cane from wagon.
442	61.58	1.0560	13.8	5.87	4.98	Oct. 23	Cane from field across railroad, amber, still green.
458	60.00	1.0550	13.6	7.60	1.97	Oct. 25	Cane from field this side railroad track, amber.
Av.	58.01	1.068	16.6	8.70	4.15		
Coefficient purity ..			52.41				

Chips from first of season to October 1, 1886.

No.	Date.	Uncorrected.		Corrected.	
		Sucrose.	Glucose.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
10	Sept. 8	5.63	8.34	5.91	8.03
11	Sept. 9	10.21	3.90	10.72	3.89
12	Sept. 9	9.08	2.15	9.58	1.70
14	Sept. 10	5.86	5.94	6.15	5.65
15	Sept. 11	9.57	2.17	10.05	1.69
17	Sept. 11	9.90	1.91	10.40	1.41
19	Sept. 13	9.30	1.24	9.76	.77
24	Sept. 14	8.58	1.94	8.96	1.51
36	Sept. 16	10.32	3.13	10.84	2.61
43	Sept. 17	9.50	3.34	9.97	2.86
49	Sept. 18	10.81	2.73	11.35	2.19
65	Sept. 20	8.28	4.98	8.69	4.57
74	Sept. 21	7.94	3.11	8.32	2.73
86	Sept. 22	5.12	7.14	5.38	6.88
90	Sept. 23	7.89	4.31	7.75	3.95
105	Sept. 25	5.74	3.89	6.03	3.60
107	Sept. 28	8.51	2.45	8.93	2.03
115	Sept. 29	11.18	1.97	11.74	1.41
121	Sept. 30	7.26	6.44	7.62	6.08
Mean		8.43	3.72	8.85	3.32

Chips from October 1 to close.

129	Oct. 1	7.88	4.03	8.28	3.63
135	Oct. 2	8.75	3.57	9.19	3.13
151	Oct. 4	6.89	3.96	7.23	3.62
135	Oct. 7	8.25	4.22	8.66	3.81
206	Oct. 8	6.22	6.66	6.53	6.35
214	Oct. 9	6.77	6.66	7.11	6.32
227	Oct. 9	10.73	3.79	11.27	3.25
238	Oct. 10	7.21	4.88	7.57	4.52
246	Oct. 11	9.08	3.93	8.43	3.53
270	Oct. 12	9.85	3.26	10.24	2.77
286	Oct. 13	3.91	7.50	4.11	7.30
289	Oct. 13	5.89	3.83	6.18	3.54
297	Oct. 14	6.65	4.71	6.98	4.38
309	Oct. 15	7.81	2.87	8.20	2.48
315	Oct. 15	7.31	3.22	7.68	2.85
325	Oct. 16	7.48	3.61	7.86	3.23
341	Oct. 17	6.55	4.99	6.88	4.66
354	Oct. 18	5.56	4.14	5.84	3.86
375	Oct. 19	6.16	4.20	6.47	3.89
391	Oct. 20	6.65	3.93	6.98	3.60
413	Oct. 21	5.77	4.19	6.06	3.80
431	Oct. 22	4.89	4.55	5.13	4.31
447	Oct. 23	4.62	4.65	4.85	4.42
461	Oct. 26	4.51	5.47	4.74	5.24
474	Oct. 27	2.48	5.47	2.69	5.26
Mean		6.68	4.48	7.01	4.15

ANALYSES OF JUICE OF CHIPS FROM CUTTERS.

These chips were taken from the cells of the battery as they were filling. A handful was taken from each cell until ten had been sampled.

The determinations were made by passing these chips through the mill and then subjecting the juice to examination in the usual way.

Mill juices from chips taken from circuit of cells.

Number.	Date.	Specific gravity.	Solids.	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
308.....	Oct. 15	1.0624	15.3	9.02	2.61
312.....	Oct. 15	1.0610	14.9	7.84	3.46
326.....	Oct. 16	1.0670	16.3	9.29	3.35
340.....	Oct. 17	1.0648	15.8	8.17	3.68
355.....	Oct. 18	1.0584	14.3	7.21	3.31
372.....	Oct. 19	1.0596	14.6	7.69	3.31
390.....	Oct. 20	1.0648	15.8	8.82	3.48
412.....	Oct. 21	1.0590	14.5	7.48	3.31
429.....	Oct. 22	1.0618	15.1	6.17	4.18
445.....	Oct. 23	1.0510	12.6	5.77	4.44
460.....	Oct. 26	1.0580	14.2	5.42	4.85
473.....	Oct. 27	1.0578	14.2	4.50	4.95
Means.....		1.0605	14.8	7.28	3.74
Means in cane.....			13.17	6.48	3.31

Purity coefficient of juice, 49.

Glucose per 100 sucrose in juice, 51.07.

Chips exhausted in bottles with and without neutralizing.

Number.	Date.	Without addition of a neutralizing substance.		Expressed juice from same.		Neutralized by—	Gives—	
		Sucrose.	Glucose.	Sucrose.	Glucose.		Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
354.....	Oct. 18	5.56	4.14	6.00	3.93	12 cc. $\frac{1}{2}$ alk.....	6.60	3.41
375.....	Oct. 19	6.16	4.20	6.60	4.10	16 cc. $\frac{1}{2}$ alk.....	7.31	3.23
391.....	Oct. 20	6.65	3.93	6.65	3.87	20 cc. $\frac{1}{2}$ alk.....	6.71	3.65
413.....	Oct. 21	5.77	4.19	6.10	4.48	Excess CaO.....	6.55	.76
431.....	Oct. 22	4.89	4.65	5.81	4.44	1 cc. bisulphite.....	4.84	4.89
447.....	Oct. 23	4.62	4.65	4.95	4.72	Excess CaCO ₃	5.17	4.00
461-2.....	Oct. 26	4.48	5.42			1 cc. CaCO ₃	5.11	5.31
461-2.....	Oct. 26	4.48	5.42			Excess CaCO ₃	4.68	5.03
461-2.....	Oct. 26	4.48	5.42			20 cc. $\frac{1}{2}$ alk.....	5.06	5.11
474-5.....	Oct. 27	2.73	5.63			2 grams CaCO ₃	3.33	4.95
Means.....		5.11	4.59	5.98	4.26		5.54	4.03

Number.	Expressed juice from same.		Mill juice from same chips.			Acidity in chips before neutralizing (malic acid).	Acidity in chips after neutralizing (malic acid).
	Sucrose.	Glucose.	Sucrose.	Glucose.	Solids.		
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
354.....	7.53	3.07	7.21	3.31	14.3	.197	Trace.
375.....	7.43	3.29	7.69	3.31	14.6	.164	Trace.
391.....	6.65	Lost.	8.82	3.48	15.8	.197	None.
413.....	6.60	Lost.	7.48	3.31	14.5	.197	None.
431.....	4.84	4.81	6.17	4.18	15.1	.181	.246
447.....	5.39	3.93	5.77	4.14	12.6	.156	.049
461-2.....			5.42	4.85	14.2	.164	.006
461.....			5.42	4.85	14.2	.164	.049
461.....			5.42	4.85	14.2	.164	None.
474-5.....			4.50	4.95	14.2	.214	.082
Means.....	6.41	4.27	6.63	3.94	14.4	.180	
In chips.....			5.90	3.51	12.82		

Diffusion juices to October 1.

Number.	Date.	Solids.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
13.....	Sept. 9...	6.8	3.29	1.89
16.....	11....	8.5	3.94	1.99
23.....	13....	9.3	6.50	1.68
26.....	14....	11.7	7.47	1.58
27.....	14....	11.2	6.17	1.42
28.....	15....	12.6	6.96	2.84
32.....	16....	10.8	5.71	1.82
35.....	17....	10.4	5.62	1.66
46.....	18....	11.9	6.59	2.18
51.....	18....	11.7	6.94	1.82
57.....	19....	11.8	5.66	2.85
64.....	20....	10.8	4.37	2.86
69.....	20....	12.8	5.59	2.46
77.....	21....	11.8	5.76	2.89
91.....	23....	11.8	6.78	2.19
94.....	24....	9.2	4.81	1.84
98.....	24....	10.7	4.53	2.28
101.....	25....	9.6	6.06	1.52
104.....	25....	8.9	4.12	1.28
108.....	28....	9.7	5.68	1.67
114.....	29....	12.6	6.76	2.92
118.....	29....	12.0	6.37	2.65
122.....	30....	14.8	7.22	4.16
Average.....		11.77	5.75	2.33

Purity, 48.93.

Diffusion juices October 1 to close.

Number.	Date.	Solids.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
123.....	Oct. 1	14.8	3.60	2.25
132.....	Oct. 2	13.7	7.01	2.32
133.....	Oct. 2	13.9	7.68	2.10
134.....	Oct. 2	13.2	7.18	2.75
139.....	Oct. 3	12.9	5.89	2.96
140.....	Oct. 3	12.7	6.51	2.65
141.....	Oct. 3	12.9	6.47	2.52
149.....	Oct. 4	9.8	4.80	2.33
152.....	Oct. 4	9.6	4.71	2.47
155.....	Oct. 4	11.5	5.42	2.28
160.....	Oct. 5	12.3	6.21	2.24
165.....	Oct. 5	13.0	6.44	2.58
166.....	Oct. 5	12.2	5.78	2.40
171.....	Oct. 5	12.2	6.08	2.23
179.....	Oct. 7	13.3	6.13	4.41
182.....	Oct. 7	12.7	5.46	4.23
183.....	Oct. 7	12.2	5.19	4.23
184.....	Oct. 7	12.2	4.50	4.41
201.....	Oct. 8	12.5	5.40	4.12
205.....	Oct. 8	11.8	5.29	3.98
216.....	Oct. 9	12.2	4.04	4.65
217.....	Oct. 9	11.3	4.08	4.07
229.....	Oct. 10	10.8	4.06	3.45
237.....	Oct. 10	11.2	4.86	3.30
244.....	Oct. 11	10.3	4.10	3.43
247.....	Oct. 11	10.3	4.32	3.15
254.....	Oct. 11	10.9	4.53	3.09
261.....	Oct. 12	13.1	5.76	3.96
262.....	Oct. 12	12.2	4.82	4.06
271.....	Oct. 12	11.9	5.44	2.41
296.....	Oct. 14	12.7	5.80	2.14
300.....	Oct. 14	11.6	4.92	2.54
313.....	Oct. 15	9.1	3.24	2.32
327.....	Oct. 16	11.6	5.14	2.98
328.....	Oct. 16	11.2	4.96	2.94
339.....	Oct. 17	11.7	5.51	2.08
356.....	Oct. 18	10.8	4.88	2.90
357.....	Oct. 18	9.8	3.64	2.96
371.....	Oct. 19	9.9	4.08	2.53
373.....	Oct. 19	10.4	4.38	2.64
389.....	Oct. 20	10.9	3.72	2.91
395.....	Oct. 20	7.2	2.33	2.08
404.....	Oct. 20	9.5	3.58	2.71

Diffusion juices October 1 to close—Continued.

Number.	Date.	Solids.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
410.....	Oct. 21	11.2	3.97	3.96
417.....	Oct. 21	11.8	3.77	4.44
428.....	Oct. 22	10.6	4.41	3.31
430.....	Oct. 22	10.1	3.95	3.37
435.....	Oct. 22	10.3	3.91	3.43
441.....	Oct. 22	10.3	3.82	3.76
444.....	Oct. 23	10.1	3.67	3.77
453.....	Oct. 23	10.1	3.41	3.63
468.....	Oct. 26	8.8	2.93	2.97
478.....	Oct. 27	7.8	2.94	2.55
Average.....		11.34	4.90	3.39

Filtered carbonatated juices before October 1.

Number.	Date.	Sucrose.	Glucose.	Solids.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
18.....	Sept. 11	4.65	1.28	8.8
22.....	Sept. 13	6.94	1.04	10.5
33.....	Sept. 16	5.96	1.50	11.1
41.....	Sept. 17	5.48	.94	11.4
47.....	Sept. 18	6.53	2.39	10.9
67.....	Sept. 20	4.78	1.82	10.7
78.....	Sept. 21	4.55	1.24	9.9
Average.....		5.56	1.46	10.47

Filtered carbonatated juices after September 30.

194.....	Oct. 7	5.73	3.11	13.0
210.....	Oct. 8	5.99	3.07	12.4
226.....	Oct. 9	5.07	3.23	12.0
235.....	Oct. 10	4.75	2.50	10.6
243.....	Oct. 11	5.07	3.89	11.9
252.....	Oct. 11	4.72	2.42	10.8
263.....	Oct. 12	6.20	2.88	12.6
301.....	Oct. 14	5.95	3.22	12.7
335.....	Oct. 16	5.82	2.48	11.8
347.....	Oct. 17	5.82	2.17	11.6
361.....	Oct. 18	4.79	2.31	10.2
382.....	Oct. 19	4.49	2.00	9.5
400.....	Oct. 20	4.09	3.48	11.1
420.....	Oct. 21	4.49	3.44	11.4
439.....	Oct. 22	4.93	2.94	11.2
451.....	Oct. 23	3.83	3.43	9.9
469.....	Oct. 26	3.19	2.20	8.1
Average.....		4.90	2.87	11.20

Sulphured juices before October 1.

Number.	Date.	Sucrose.	Glucose.	Solids.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
34.....	Sept. 16	5.96	1.70	11.6
42.....	Sept. 17	5.77	1.02	12.7
48.....	Sept. 18	6.65	1.53	11.4
68.....	Sept. 20	4.53	2.13	10.7
79.....	Sept. 21	4.55	1.24	9.9
86.....	Sept. 24	4.60	2.46	10.6
Average.....		5.34	1.65	11.15

Sulphured juices after September 30.

195.....	Oct. 9	6.78	3.11	13.2
211.....	Oct. 8	5.89	3.17	12.6
225.....	Oct. 9	5.09	3.12	12.2
236.....	Oct. 10	4.78	2.63	10.6
253.....	Oct. 11	4.78	2.54	11.0
264.....	Oct. 12	6.20	2.97	12.7
302.....	Oct. 14	5.87	3.50	13.2
336.....	Oct. 16	5.89	2.67	12.5
348.....	Oct. 17	6.18	2.44	12.4
362.....	Oct. 18	5.12	2.35	10.8
383.....	Oct. 19	4.58	2.14	9.7
401.....	Oct. 20	4.12	3.64	11.2
421.....	Oct. 21	4.54	3.53	11.7
440.....	Oct. 22	4.89	3.04	11.4
452.....	Oct. 23	3.90	3.48	10.8
470.....	Oct. 26	3.23	2.81	7.8
Average.....		5.11	2.90	11.5

Waste waters, before October 1.

Number.	Date.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>
20.....	Sept. 13	0.00	0.00
58.....	Sept. 19	.24	.....
76.....	Sept. 21	.16	.10
99.....	Sept. 24	.....	.25
111.....	Sept. 28	.67	.....
117.....	Sept. 29	.81	.26
124.....	Sept. 30	.....	.14
Average.....		.27	.15

Waste waters, after September 30.

136.....	Oct. 2	.....	.17
142.....	Oct. 3	.....	.43
145.....	Oct. 3	.....	.15
153.....	Oct. 4	.....	.91
156.....	Oct. 4	.....	.43
161.....	Oct. 5	.....	.30
164.....	Oct. 5	.....	.35
167.....	Oct. 5	.....	.48
172.....	Oct. 5	.....	.21
186.....	Oct. 6	.....	.14
187.....	Oct. 6	.....	.08
188.....	Oct. 6	.....	.08
189.....	Oct. 6	.....	.11
202.....	Oct. 8	.....	.21
208.....	Oct. 8	.....	.19
218.....	Oct. 9	.....	Trace.
219.....	Oct. 9	.....	.15
230.....	Oct. 10	.....	.11
248.....	Oct. 11	.....	Trace.
250.....	Oct. 11	.....	.10
265.....	Oct. 12	.....	.20
266.....	Oct. 12	.....	.10
273.....	Oct. 12	.....	.10
299.....	Oct. 14	.....	.10
303.....	Oct. 14	.....	.11
316.....	Oct. 15	.....	.62
330.....	Oct. 15	.....	Trace.
331.....	Oct. 16	.....	Trace.
343.....	Oct. 17	.....	Trace.
358.....	Oct. 18	.....	None.
381.....	Oct. 19	.....	Trace.
405.....	Oct. 20	.....	Trace.
406.....	Oct. 20	.....	.20
438.....	Oct. 22	.....	Trace.
457.....	Oct. 23	.....	Trace.
Average (35).....		.....	.17

Waste chips, before October 1.

Number.	Date.	Glucose.
		<i>Per cent.</i>
26.....	Sept. 14	.15
35.....	Sept. 16	.20
40.....	Sept. 17	.10
52.....	Sept. 18	.10
56.....	Sept. 19	.10
81.....	Sept. 21	.23
92.....	Sept. 23	.20
106.....	Sept. 25	.38
110.....	Sept. 28	.29
116.....	Sept. 29	.63
Average.....		.24

Waste chips, after September 30.

137.....	Oct. 2	.40
143.....	Oct. 3	1.20
144.....	Oct. 3	.71
154.....	Oct. 4	.79
157.....	Oct. 4	1.11
162.....	Oct. 5	1.52
165.....	Oct. 5	.70
168.....	Oct. 5	.85
173.....	Oct. 5	.65
190.....	Oct. 7	.65
191.....	Oct. 7	.40
192.....	Oct. 7	.34
193.....	Oct. 7	.30
203.....	Oct. 8	.35
209.....	Oct. 8	.22
220.....	Oct. 9	.55
221.....	Oct. 9	.41
239.....	Oct. 10	.42
251.....	Oct. 11	.62
256.....	Oct. 11	.22
272.....	Oct. 12	.62
274.....	Oct. 12	.34
275.....	Oct. 12	.80
298.....	Oct. 14	.41
304.....	Oct. 14	.39
314.....	Oct. 15	.56
329.....	Oct. 16	.18
345.....	Oct. 17	.24
359.....	Oct. 18	Trace.
379.....	Oct. 19	.69
396.....	Oct. 20	.30
418.....	Oct. 21	.42
436.....	Oct. 22	.36
454.....	Oct. 23	.41
Average (33).....		.52

Semi-sirup.

Number.	Date.	Solids.	Sucrose.	Glucose.	Specific gravity.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
62.....	Sept. 20	37.5	23.02	5.13	1.1660
204.....	Oct. 7	60.2	32.10	17.24	1.2910
228.....	Oct. 10	51.1	27.50	15.22	1.2388
255.....	Oct. 11	30.0	15.80	9.90	1.1296
291.....	Oct. 14	46.4	25.20	11.37	1.2130
307.....	Oct. 15	55.9	27.90	17.86	1.2663
319.....	Oct. 15	55.9	31.70	12.50	1.2660
337.....	Oct. 17	65.7	34.60	18.21	1.3243
353.....	Oct. 18	37.5	19.90	10.75	1.1994
368.....	Oct. 18	57.5	30.40	13.90	1.2750
425.....	Oct. 22	58.4	24.60	18.87	1.2900
456.....	Oct. 23	50.5	22.10	16.39	1.2356
Average (12).....		50.5	26.23	11.94	

Masse-cuites.

Number.	Water.	Solids.	Ash.	Sucrose.		Reducing sugar.
				Direct.	Inversion.	
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
12	18.98	81.02	04.35	46.20	47.84	22.72
40	19.41	80.59	05.09	40.00	41.14	21.51
45	18.99	81.91	04.6	43.60	45.82	24.04
57	19.34	80.66	08.4	44.40	46.92	24.75
92	17.60	82.40	04.9	44.20	46.93	21.93
306	16.69	83.31	04.94	42.60	44.98	21.98
332	35.14	64.86	05.46	47.10	48.73	19.53
338	17.77	82.23	04.45	45.70	46.97	20.83
350	22.21	77.79	05.03	38.80	40.92	20.32
379	14.58	85.42	05.43	47.50	48.20	21.19
387	16.94	83.06	03.16	48.80	50.42	16.56
Means	19.75	80.35	5.07	44.45	46.26	21.39

Molasses.

4683	26.42	73.58	.0539	32.80	34.48	21.33
4685				32.60		42.37
4681	18.07	81.93	.0540	35.10	36.94	20.83
4684	30.72	69.28	.0506	33.50	37.17	25.25
4686	23.12	76.88	.0502	30.3	33.41	28.10

Sample of sugar: Sucrose, 98.16; glucose, .07.

Acidity in juices.

[Calculated as malic acid.]

Mill juices.			Diffusion juices.		
No.	Date.	Per cent.	No.	Date.	Per cent.
179	Oct. 8	.280	184	Oct. 7	.321
180	Oct. 8	.255	201	Oct. 8	.174
213	Oct. 9	.201	216	Oct. 9	.263
232	Oct. 10	.280	229	Oct. 10	.273
242	Oct. 11	.188	244	Oct. 11	.295
258	Oct. 12	.147	327	Oct. 16	.335
326	Oct. 16	.188	356	Oct. 18	.308
355	Oct. 18	.188	371	Oct. 19	.147
372	Oct. 19	.126	417	Oct. 21	.161
412	Oct. 21	.134	430	Oct. 23	.362
429	Oct. 22	.134	453	Oct. 23	.348
442	Oct. 23	.147			
Means.		.189	Means		.272

Acidity in chips.

No.	Date.	Per cent.	No.	Date.	Per cent.
105	Sept. 25	.234	286	Oct. 13	.181
107	Sept. 28	.222	289	Oct. 13	.164
115	Sept. 29	.226	325	Oct. 16	.164
121	Sept. 30	.246	341	Oct. 17	.173
129	Oct. 1	.214	354	Oct. 18	.197
135	Oct. 2	.197	375	Oct. 19	.164
151	Oct. 4	.181	391	Oct. 20	.197
185	Oct. 7	.164	413	Oct. 21	.197
206	Oct. 8	.181	431	Oct. 22	.181
214	Oct. 9	.185	447	Oct. 23	.156
227	Oct. 9	.164	461	Oct. 26	.164
238	Oct. 10	.230	474	Oct. 27	.214
246	Oct. 11	.148			
270	Oct. 12	.246	Means..		.192

Moisture in chips and bagasse.

Fresh chips.		Exhausted chips.		Fresh bagasse.		Exhausted bagasse.	
No.	Per cent. moisture.	No.	Per cent. moisture.	No.	Per cent. moisture.	No.	Per cent. moisture.
206	71.59	208	89.58				
234	74.18	226	88.35				
238	75.82	230	89.68				
246	77.80	251	89.76				
270	73.67	272	88.87				
286	74.53						
289	75.33						
297	74.60	298	88.94				
308	73.70	314	88.62				
325	73.58	329	90.43				
341	73.10	345	88.86				
354	76.37	359	87.57	367	57.79	368	67.73
375	77.57	379	84.89	384	62.91	385	66.57
391	78.15	396	86.41	402	57.27	403	63.74
413	71.77	418	86.73	422	56.94	423	63.06
481	76.96						
431	76.15	454	87.71				
447	74.78						
Means.	74.95		88.31		58.73		65.28

Table showing weight of twelve press-cakes.

No.	Pounds.	No.	Pounds.
1	26	7	24
2	24	8	24
3	24	9	24
4	24	10	23
5	25	11	24
6	25	12	24.5
		Mean.	24.3

Moisture in filter-press cake.

No.	Per cent. moisture.	No.	Per cent. moisture.
278	45.24	369	45.98
293	45.61	383	44.54
305	47.06	411	48.88
324	45.63	424	44.11
342	45.71	446	45.89
349	52.94	Mean.	46.45

Press-cakes.

[In dry substance.]

Serial No.	Organic matter.	Carbonic acid CO ₂ .	Insoluble and silica.	Iron and alumina.	Lime.	Magnesia.	Phosphoric acid P ₂ O ₅ .	Sulphuric acid SO ₃ .	Manganese.	Total.
4589	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
4650	19.14	29.08	2.18	7.23	37.87	1.32	2.05	65	Traces.	99.47
4646	.....	26.55	1.01	5.72	43.31	.71	.88	.....	.....	.....
4647	.....	32.63	1.67	5.01	43.79	.56	.62	1.05	.....	.....
4648	.....	31.49	1.67	3.15	42.67	.70	.84	.32	.....	.....
4649	.....	31.67	1.68	4.53	42.45	.32	.29	.92	.....	.....
4669	23.28	29.90	.86	1.65	41.90	.60	1.20	.55	.....	99.44
4637	17.80	31.78	.67	1.85	44.51	.76	.63	.90	.....	99.90
4657	17.09	33.44	.67	3.96	43.72	.33	.69	.31	.....	99.73
4658	15.27	33.50	1.45	4.07	45.36	.46	.39	.35	.....	101.25
4699	17.90	32.35	.67	1.55	44.45	.69	.63	1.14	.....	99.35
4675	11.88	31.95	.58	1.89	45.09	.56	.60	.98	.....	99.93
.....										

[In the organic matter.]

Number.	Sucrose.	Glucose.	Nitrogen equiva- lent to albumen.	Water in original cake.
	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
4589.....	.00	.74	2.66	39.07
4650.....	.00	.83		
4646.....	1.90	2.83	4.65	45.24
4647.....	2.20	3.77	2.15	45.61
4648.....	2.43	3.08		47.06
4649.....	2.41	5.02	5.70	45.63
4660.....	.93	.83	1.08	52.84
4687.....	.07	Trace.	.90	45.96
4657.....	3.12	3.00	.91	44.54
4658.....	2.21	4.56	1.59	48.88
4659.....	1.50	3.50	1.08	44.11
4675.....	2.41	4.05	.33	

DISCUSSION OF THE DATA.

It is evident from the foregoing analyses of limestones that, with few exceptions, the quality of stone used was exceedingly poor. The importance of good stone is at once evident, since bad stone is liable to "hang up" in the furnace, give a poor quality of lime for the defecation, and a weak gas for the carbonatations.

The quality of the gas employed during the season was fairly good. At first, by feeding too much coke with the limestone, large quantities of carbonic oxide were produced. The carbonic dioxide formed at the bottom of the furnace was reduced to CO by the white-hot coke above. After the laborers learned the proper manipulation of the kiln no further trouble was experienced from this cause. The carbonic oxide was always accompanied by a peculiarly unpleasant odor, and made the laborers about the carbonatation pans dizzy and ill. One of them fainted from the effects of the gas on the day it contained the largest quantity of carbonic oxide.

The percentage of CO₂ in the gas from time to time during the manufacturing season is shown by the following analyses :

No.	Date.	CO ₂ .	Remarks.
		<i>Per cent.</i>	
	Sept. 28	11.00	
2	Sept. 29	13.00	
3	Sept. 30	15.50	
4	Oct. 2	10.06	Morning.
5	Oct. 2	15.80	Noon.
6	Oct. 2	14.0	Night.
7	Oct. 3	21.0	
8	Oct. 4	22.4	Morning.
9	Oct. 4	20.6	Afternoon.
10	Oct. 5	21.0	
11	Oct. 6	23.0	
12	Oct. 9	22.5	
13	Oct. 10	22.5	
14	Oct. 11	23.0	
15	Oct. 19	15.0	

It is seen that when the men had learned the proper use of the furnace the percentage of CO₂ was kept pretty constantly above 20. The an-

alysis No. 15 was made a day after the fires in the furnaces had been stopped. It showed that when internal combustion alone was practiced the percentage of CO_2 rapidly decreased. A gas containing from 20 to 25 per cent. CO_2 is well suited to carbonatation.

VOLUME OF GAS EMPLOYED.

The double-acting pump for supplying gas to the pans had the following capacity:

	Inches.
Diameter of cylinder.....	17.5
Length of stroke.....	21.25

The mean rate of motion for the pump was 40 per minute; hence the total quantity of gas delivered per minute was 236 cubic feet.

The volume of CO_2 furnished per minute is obtained by multiplying the above number by the mean percentage of CO_2 in the gas, viz, $236 \times .20 = 47.2$ cubic feet.

In metric terms 47.2 cubic feet are equal to 1,336 liters.

With gas of a good quality, say 25 per cent. CO_2 , a pump of the capacity described would easily furnish gas for working 200 tons of cane per day.

DOUBLE CARBONATATION.

A few experiments were made to determine whether or not double carbonatations could be practiced with sorghum juices.

It was found that if from two to four tenths grams of lime per liter were left in the juice of the first carbonatation the filtration took place more readily, and the juice was somewhat purer.

In double carbonatation some additional lime is added to the hot juice from the filter-presses, and the injection of CO_2 continued until the liquid is neutral. Pans were put up and this method given a trial. But with a sugar-juice as rich in glucose as that afforded by sorghum, this procedure is not applicable.

For convenience, and to note the effects of a heavy frost, the analytical data relating to the juices, &c., are given in two parts, viz, those obtained before October 1 in the first part, and those after September 30 in the second. It is believed that every analysis made has been recorded, since in the circumstances arising from the result of the experiments even those which seem to have no value have been considered worthy of finding a place.

MILL-JUICES.

The samples of cane expressed by the small mill were taken without any purpose of illustrating any theory. The object in selecting them was to get as fair an idea as possible of the character of the cane entering the factory.

A study of the tables reveals the most surprising variations in the composition of the canes, varying from a quality of high sugar-producing value to one worthless for this purpose.

As has already been pointed out, the generally poor character of the

cane is due to much of it being overripe, especially in the case of the Amber variety. But the chief trouble arose from delay in handling the cane due to defects in the machinery already pointed out. In some cases, however, canes cut for two or three days, when kept, for example, in the middle of a car-load, from changes of temperature, preserved their sugar contents remarkably well. In general, however, the results of the work emphasized the importance of a prompt handling of the canes after they have been cut.

With such canes as are indicated by the analyses of the mill-juices it would be hopeless to expect to manufacture sugar profitably by any process whatever.

The amount of glucose per hundred of sucrose in the first series of analyses is 38.21; after September 30 it is 47.72.

DIRECT EXTRACTION OF THE CHIPS.

The determination of the sugars in the expressed juice of the cane is not a satisfactory method of determining the sugar in the cane itself. Did all canes contain the same percentage of juice, and were all the juice both that expressed and that remaining in the canes, of the same composition, no other method of analysis would be necessary. Since neither of these conditions obtain, however, in actual experience, I was led to try some other process. The one finally adopted is described in full in the Bulletin de l'Association des Chimistes, and published in Paris November 15, 1884.

Fresh sorghum canes were cut into fine chips and treated for an hour in a closed bottle with water at the boiling temperature.

The analyses of the liquid obtained showed that the chips had the following composition:

No.	Sucrose in cane, by direct estimation.	Sucrose in cane, calculated from composition of the juice, 89 per cent.	Glucose in cane, direct.	Glucose in cane, calculated.
1	<i>Per cent.</i> 8.71	<i>Per cent.</i> 8.68	<i>Per cent.</i> 1.95	<i>Per cent.</i> 2.07
2	17.98	7.82	1.84	1.86

* Mean of six analyses.

† Mean of four analyses.

It is seen by these analyses that the results obtained by the two methods agree very closely.

A large number of experiments has also shown that equally as satisfactory results are obtained with sugar-cane.

When, however, in the case of sorghum, the canes have already begun to deteriorate, and the sucrose is already partly inverted, it is found that this method of analysis causes a considerable inversion. A similar inversion, although to a less extent, takes place in the cells of the battery.

After the close of the season a comparative study was made of the amount of this inversion, and the results of these studies show clearly

that the trouble is due to the acids of the cane chiefly to those formed by the partial fermentation which has produced the inversion of the sugar, or else the increased susceptibility of the sucrose remaining to the inverting action of the organic acids.

The results of these analyses are given under "analytical data."

DIRECT ESTIMATION OF SUGAR IN CHIPS.

The samples were taken as before described. Since only a small quantity could be used in each analysis (50 grams, circa), single results are not strictly mean indications of the content of the whole in sugar. The means, however, will give a fair idea of the composition of the chips.

The extraction of the sugar was made in the following way:

The weighed sample of fresh chips (48.9 grams) is placed in a strong extraction-flask and water added until the total volume (marked on neck of flask) is 305 cubic centimeters. The five cubic centimeters in excess of 300 is the allowance made for the fiber of the cane, which, for the quantity taken, amounts to five grams, and occupies a volume of about 5 cubic centimeters. The bottle is then tightly stoppered and heated at 100° for an hour, being frequently shaken. The method is based on the supposition that by this treatment complete diffusion has taken place, and that the free liquor and that in the pores of the pulp have the same composition. The liquor is then filtered, 100 cubic centimeters representing 16.3 grams of the original chips, treated with acetate of lead, made up to 110 cubic centimeters, and polarized. After adding one-tenth the reading gives the percentage of sucrose present.

A discussion of the errors attending this method of analysis will be given further along.

Following are the numbers obtained by this method of analysis, and also the provisional correction which has been adopted.

This method rests on the assumption that the liquor within and without the chips has the same constitution. This assumption is probably incorrect when the canes have deteriorated.

Subjected to an analytical test the following data were obtained:

No.	Sucrose in liquor.	Sucrose in juice from chips.	Glucose in liquor.	Glucose in juice from chips.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	6.65	6.65	3.93	3.87
2	5.77	6.10	4.10	4.48
3	4.89	5.61	4.55	4.44
4	7.81	8.19	2.87	2.57
5	7.48	8.31	3.61	3.33
6	6.55	6.55	4.09	4.04
7	5.50	6.00	4.14	3.93
8	6.60	7.53	3.41	3.07
9	6.16	6.60	4.20	4.10
10	7.31	7.43	3.23	3.29
11	6.71	6.65	3.65	-----
12	4.84	4.84	4.80	4.81
13	4.62	4.95	4.65	4.72
14	5.17	5.39	4.00	3.93
Means	5.75	6.06	3.99	3.87

Parts of glucose per 100 sucrose in free liquor, 69.94.

Parts of glucose per 100 sucrose in juice from the chips, 55.60.

It is seen from the above data that the mean total sugar in the free liquor equals 9.44 per cent. and in the juice expressed from chips from same equals 9.43 per cent.

This method of extraction with sorghum chips is, therefore, open to the objection of inverting a portion of the sucrose when the canes are not fresh. It is seen that 4 per cent. of sucrose present has been changed into reducing sugar. As the second of the analyses shows, this change has taken place entirely without the cell, the composition of the juice remaining in the cells being sensibly the same as that of the normal juice of the cane.

These results are of extreme interest. They show most conclusively that in the process of diffusion at a high temperature there is a notable inversion of the sucrose when the canes are not in proper condition. Further than this, it is shown that this inversion takes place in the sugar in the free liquor and not in the sugar remaining in the fiber of the cane. In nearly every case the free liquor was poorer in sucrose and richer in glucose than that in the pulp.

To correct the acidity in the battery, and thus avoid inversion, the following methods were tried:

(1) The limed juice used in the carbonatation-tanks was added to the cell of fresh chips little by little until enough was used to neutralize the acid. Two serious objections were found to this procedure: (a) The proper control of the quantity to be added was impossible. The juice would at times become strongly alkaline and highly colored; (b) the lime seemed to prevent the extraction of the sugar. The total solids of the diffusion juice under this treatment ran down rapidly from 11 per cent. to 4 per cent. This was due either to the coagulated albuminous matters preventing the osmotic action or to the formation of an insoluble lime sucrate, which remained in the chips. The method, therefore, had to be abandoned.

(2) Lime-water was added to the tank supplying the diffusion battery in such proportions as to furnish alkali enough to nearly neutralize the free acidity of each cell of chips. This water entered the cell next to be emptied of exhausted chips. All the lime in suspension was at once filtered out, and that in solution was not sufficient to neutralize the acidity in the cells in advance.

(3) Addition of lime bi-sulphite. To test the efficiency of lime bi-sulphite in preventing inversion during extraction it was added to the water in the feed-tank for the battery in quantities equal to one-half gallon for each diffusion. It was also used in the extraction flask with the results to follow.

(4) The addition of freshly precipitated carbonate of lime to the extraction bottle. This method was suggested by Prof. M. Swenson. The analyses show that the acidity was diminished by two-thirds, and the inversion of the sucrose largely prevented by the treatment. If a few pounds of such a carbonate could be evenly distributed in the

chips, it appears reasonable to suppose that this inversion would not take place.

Analytical data obtained in above experiments.

	Sucrose.	Glucose.	Exhausted chips, total sugars.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Diffusion juice with lime in cells of fresh chips..	2.33	2.08	2.58
Compare analyses of same day of diffusion juice before the addition of lime	3.72	3.91	.57
Fresh chips used same day:			
Ordinary method.....	6.65	3.93	
Expressed juice from above.....	6.65	3.87	
With alkaline extraction, NaO	6.71	3.65	
Expressed juice from same.....	6.65	lost.	
Mill juice from fresh chips same day.....	8.82	3.48	

	<i>Per cent.</i>
The diffusion juice from diffusion before treatment had of total sugars.....	7.63
Exhausted chips.....	51
Total sugar.....	8.14
The diffusion juice from chips treated with lime:	
Total sugars	4.41
In exhausted chips	2.58
Total sugar	6.99

Whence it appears that by the coagulated albumen occluding the pores of the cells there was a loss of about 2 per cent. of sugar and in addition a small loss due to the formation of a lime sucate.

In the extraction bottle, when the alkalinity was produced by lime instead of soda, this loss of sugar did not appear. The lime, however, diminished the percentage of glucose in a marked degree. This is shown by the following analyses:

	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>
Extracted with water.....	5.77	4.19
Juice from the chips.....	6.10	4.48
Extracted with lime water.....	6.55	.76
Juice from the chips.....	6.60	not determined.
Diffusion juice made by adding lime to supply tank of battery:		
First	3.95	3.37
Second	4.41	3.31
Third. Diffusion juice with bi-sulphite added to supply tank, half gallon for each cell.....	3.91	3.43
Using bi-sulphite in extraction flask the following data were obtained:		
Mill juice from fresh chips	6.17	4.18
Ordinary extraction	4.89	4.55
Juice pressed from chips of above.....	5.61	4.44
Extraction with addition of 1 cc. bi-sulphite to each bottle	4.84	4.86
Juice pressed from chips of above.....	4.84	4.81

	First comparison.		Second comparison.	
	Sucrose.	Glucose.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Usual method.....	5.56	4.14	6.16	4.20
With alkali.....	6.60	3.41	7.31	3.23

In these two cases there was an apparent inversion of 20 per cent. of the sucrose. Another trial with better chips gave the following results:

	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>
Chips treated in the usual way	6.65	3.93
Treated after addition of 20 cc., one-tenth alkali	6.71	3.65
(In this case the inversion was only 1 per cent.)		
Another trial with very poor and sour chips:		
By direct method	4.51	5.47
With 1 cc CaCO_3	5.11	5.63
Sulphite	5.11	4.95
Means	5.11	5.33
(Showing an apparent inversion of 10 per cent.)		
Same chips with an excess of CaCO_3	4.68	5.03
(Showing an apparent inversion of 3 per cent.)		

Taking all the data into consideration, it appears to be fair to assume that the inversion during the extraction in the flask was not more than 5 per cent. of the sucrose present, while during the first of the season it was doubtless much less. A strong corroboration of the justice of this allowance is found in the fact that the purity of the chips analyzed up to October 1, with the correction noted, is nearly exactly the same as that of the mill juices.

In the diffusion battery, where the temperature was kept at about 70° C., the inversion was not so great.

In any case, however, these analyses can only be accepted provisionally. The reliable analyses are those of the mill and diffusion juices. Since the results for the chips, however, agree so closely with those known to be correct, they can be accepted for all practical purposes.

Since the extraction in a flask does not afford a direct method of determining the total soluble solids in the chips, this must be done by calculation.

For this purpose the same ratio between glucose and other substances not sugar in solution is taken as that existing in the corresponding mill juices.

Applying this principle, we find that up to October 1 the following data are accessible.

	<i>Per cent.</i>
Glucose in mill juices	4.01
Solids not sugar in mill juices	3.06
Ratio, 1 glucose to .76.	
Glucose in chips	3.32
Not sugars calculated	2.52
Sucrose	8.85
Total solids in chips	14.69

After September 30 the numbers are as follows:

	Per cent.
Glucose in mill juices	4.15
Not sugars in mill juices	3.75
Ratio 1 glucose to .90 not sugars.	
Glucose in chips	4.15
Not sugars in chips (calculated).....	3.74
Sucrose.....	7.01
Total solids.....	14.90
Purity of chips before October 1.....	60.5
Purity of chips after September 30.....	47.1

SAMPLES OF CHIPS—CORRECTED NUMBERS.

A full discussion of the data obtained by the analyses of the chips entering the battery has already been given.

Per hundred parts of sucrose the glucose was as follows:

	Per cent.
Before October 1.....	37.52
After September 30	59.18

A comparison of these ratios with those of the mill juices affords a confirmation of the supposition already expressed that as the canes deteriorate the rate of inversion on heating in a closed flask is greatly increased.

The analyses, therefore, of the mill juices after September 30 give the only fair idea of the character of the cane worked up to October 15. After that date the analyses of the juice of the chips pressed out by the experimental mill gives the best results possible. Sampled as the chips were, by taking an equal portion from each cell and mixing these subsamples from ten cells together, the juice expressed therefrom is a fair representation of the character of the chips entering the battery.

JUICE FROM CHIPS PASSED THROUGH EXPERIMENTAL MILL.

From the analyses of the juices it is seen that the chips entering the battery from October 15 to the close of the season contained:

	Per cent.
Sucrose.....	6.48
Glucose.....	3.31
Glucose per hundred of sucrose.....	51.07

Leaving out of the computation the analyses of the chips in closed bottles, the following mean character of the cane for the entire season is obtained:

	Total solids.	Sucrose.	Glucose.
	Per cent.	Per cent.	Per cent.
Before October 1.....	15.63	9.34	3.57
After September 30	14.77	7.74	3.79
After October 14.....	12.17	6.48	2.31
Means	14.56	7.85	3.52

Mean purity, 53.9; mean glucose per hundred sucrose, 43.84.

Available sugar, calculated by taking difference between sucrose and all other solids, viz, 1.15 per cent. = 23 pounds per ton.

It will be interesting to compare these numbers with those obtained at Magnolia Station, La., in 1885, and recorded in Bulletin No. 11, pp. 11, 12.

	Per cent.
Total solids in cane	14.22
Total sucrose in cane	10.90
Total glucose in cane	.92
Mean purity	76.6
Mean glucose per 100 sucrose	8.44

Available sugar calculated as before, viz, 7.58 per cent. = 151.6 pounds per ton.

It thus clearly appears from a careful study of the analytical data that the sorghum canes entering the battery at Fort Scott were totally unfit for sugar-making. Those who are disposed to find fault with the experiments because more sugar was not made would do well to consider these facts.

No known process, save an act of creation, could have made sugar successfully out of such material.

If nothing better than this can be obtained, then it is time to declare the belief in an indigenous sorghum-sugar industry a delusion. This subject will be mentioned again in the summary.

A general review of the data connected with this interesting problem shows that with fresh chips of fine quality, the natural acidity is capable of producing no appreciable inversion during treatment in an extraction flask or while under pressure in the battery. With the deterioration of the cane, however, and consequent increasing acidity, this inversion becomes very great. In other words, the natural acids of the cane, such as malic and aconitic, are incapable of producing any appreciable inversion; but the accidental acid (acetic) which comes from deterioration may cause an inversion of the sucrose in a most marked degree. The most practical method of avoiding this danger appears to me to be a mechanical contrivance which will sprinkle evenly over the entering chips 2 or 3 pounds of fine slaked lime or double that quantity of fine calcium carbonate to each cell of chips.

As has already been noted, every other attempt to neutralize the dangerous acids of the cane in a practical way has failed.

DIFFUSION JUICES.

The ratio of glucose to sucrose (per hundred) in the diffusion juices was as follows:

	Per cent.
Before October 1	39.95
After September 30	68.15

These results show that before frost the inversion of the sucrose in the battery was nil, but that after frost this inversion was very marked. This fact is also emphasized by another, viz, that before frost the full battery of 14 cells was used, but that afterwards 8, 10, and 12 cells only

were employed. Thus before frost the chips in the battery were longer under pressure than afterwards, and I may add that the temperature was also higher. These facts corroborate the statement already made that when once the process of inversion has commenced it goes easily and rapidly forward under the combined influence of time and an elevated temperature. Before such deterioration begins a temperature of even 100° C, can be maintained for an hour without notable injury.

A further fact which is illustrated by the analyses of the diffusion juices from uninjured canes is that the diminished purity is produced solely by the extraction of gum and chlorophyll, chiefly from the blades and sheaths, and that this injury can be avoided by a proper cleaning of the canes.

With clean canes and those in which the sucrose is still uninjured no alkaline substance will have to be used in the battery. When, however, deteriorated canes are used, some such application will be necessary to save the sucrose from further inversion. As has already been pointed out, finely powdered lime or calcium carbonate evenly distributed over the chips offers the simplest solution of the difficulty.

CARBONATATED JUICES.

The ratio of glucose to sucrose (per hundred) was as follows:

	Per cent.
Before October 1	26.28
After September 30	57.40

In both cases we find a marked decrease in the quantity of glucose. This produces a corresponding increase, usually reckoned at twice the quantity of glucose destroyed, in the *rendement* of crystallized sugar.

If the resulting molasses could be preserved—and this can be done, as will be pointed out later—this increase in yield could be used without any deleterious effect whatever. The analytical data confirm the opinion already expressed, and agree with the experience of sugar-makers wherever the process has been tried, that the process of carbonatation gives a larger yield of crystallizable sugar than can be obtained by any other known method of defecation.

SULPHURED JUICES.

Comparing again the glucose per hundred of sucrose, the following data are obtained:

	Per cent.
Before October 1	30.86
After September 30	36.84

In the first part of the season the treatment with sulphurous acid shows a very slight inversion of the sucrose. This was accomplished by long treatment of the juice with the acid, in the hope that a lighter-colored sirup might be produced.

In the second half of the season no inversion took place from this source. As I will point out further along, the treatment of the juice at

this point by sulphur should be replaced by the addition of phosphoric acid.

The sulphurous acid should be applied afterwards, but in the double effect and strike pans.

WASTE WATERS AND EXHAUSTED CHIPS.

The amount of waste water was very small, compressed air having been uniformly used to drive the water from the cell next to be discharged.

In the estimation of the sugar the sucrose was first inverted and the whole sugar estimated as glucose. The mean percentage of both sugars in the waste waters after September 30 was .17 per cent. Since the mean glucose per hundred of sucrose for the season was nearly 44, the respective quantities of sucrose and glucose were as follows :

	Per cent.
Sucrose	.11
Glucose.....	.06

In the exhausted chips before October 1, by the same method of calculation, there was of—

	Per cent.
Sucrose	.16
Glucose.....	.08

After September 30 the numbers are as follows :

	Per cent.
Sucrose.....	.35
Glucose.....	.17

This increase in the sugar left in the chips was due to cutting out a large portion of the battery, especially during the first week in October. At this time often only six cells were under pressure, but the result is seen in the large quantities of total sugar left in the chips, amounting in one instance to 1.52 per cent.

After the 6th of October nine or ten cells were kept under pressure, and the content of sugar left in the chips was correspondingly diminished.

Sorghum, however, lends itself to diffusion more readily than any other sugar-producing plant, and a battery of ten cells properly managed would give good results as far as extraction is concerned.

PRESS CAKES.

The mean weight of the press cakes was 24.3 pounds. The mean content of moisture was 46.45 per cent.

Since considerable time elapsed from the time of sending the cakes from Fort Scott until they were analyzed at Washington, a considerable inversion of the sucrose took place.

The mean total sugar in the twelve press-cakes examined was 4.42 per cent.

Dividing this, as before, between the two sugars, we find, of—

	Per cent.
Sucrose.....	2.97
Glucose.....	1.45

When extra care was taken in washing the cakes, as in the case of the Louisiana experiments, to be later described, only a trace of sugar was left in them.

A glance at the composition of the cake will show its value as a fertilizer.

The quantity of lime used was nearly $1\frac{1}{2}$ per cent. of the weight of the cane entering the battery.

RESULTS OF WORK.

The average weight of chips in the cells was 1,900 pounds.

From the beginning of the first attempts to run the machinery (September 13) until it was found possible to save the product (September 29) 499 diffusions were made, amounting to 948,100 pounds. After beginning to save the product (September 29) until suspension of work (October 26) 1,945 diffusions were made, amounting to 3,695,500 pounds. The total weight of cane, seed, and blades received from the field after September 19 was 3,120 tons.

The weight of chips diffused was 2,322 tons. The weight of seed, tops, blades, and cleanings (by difference) was 798 tons.

Following is the number of cells of chips used each day after September 19. Before that date no separate daily account was kept:

Date.	Number of cells cut.	Date.	Number of cells cut.	Date.	Number of cells cut.
Sept. 20	30	Oct. 2	69	Oct. 14	80
21	59	3	56	15	75
22	44	4	79	16	100
23	67	5	55	17	85
24	89	6	53	18	55
25	63	7	66	19	53
26	66	8	59	20	91
27	41	9	70	21	102
28	33	10	79	22	106
29	75	11	92	23	99
30	66	12	85	26	42
Oct. 1	67	13	66		
Total				2,419	

About one-third of the cane received was partly stripped of its blades. It appears from the above figures that the seed tops, blades, and sheaths of the cane will amount to nearly 30 per cent. of the entire weight. It must also be remembered that much of the blades, sheaths, &c., was not removed by the very imperfect cleaning apparatus employed, and this weight is included in that of the "clean chips."

STATEMENT SHOWING RATIO OF SEED HEADS TO WEIGHT OF CANE, RATIO OF CLEANINGS FROM BLOWER, AND QUANTITY OF CLEAN CANE CHIPS PER CELL.

Weight of cane taken.....	pounds..	118,480
Weight of seed tops	do....	21,875
Weight of cleanings.....	do....	7,580
Weight clean cane chips.....	do....	89,025
Weight of each cell full of clean chips.....	do....	1,894
Seed heads to total weight of cane.....	per cent..	18.47
Cleanings total weight of cane.....	do....	6.40
Clean chips on total weight of cane.....	do....	75.13

The cane used in the above experiments was stripped in the field. The "cleanings" comprised the blades not removed and sheaths, &c., blown out by the fanning-machine. Much of these impurities was not removed. The sugar obtained was of a fair marketable kind and found a ready sale. The molasses was of a dark color and a poor quality.

The weight of *masse-cuite* was determined on a portion of the product by Mr. Swenson. He placed it at a mean of 12 per cent. of the weight of the chips entering the battery. The weight of melada obtained from the 2,322 tons was, therefore, 557,280 pounds, or 46,440 gallons.

At the present writing (November 15) all of the sugar has not been swung out, but the product will be about fifty thousand pounds. This is indeed a discouraging yield and quite in contrast with the phenomenal quantity obtained from sugar-cane from Louisiana, to be mentioned further along. If a proper crystallizing room had been provided by the company the yield of sugar would have been much larger. On November 2 the different parts of the crystallizing room were found to be of the following temperatures:

	Degrees F.
Northeast corner	84
North center.....	84
Three feet above floor, under north steam-drum	72
Northwest corner	75
In upper layer of sirup in wagon, under south steam-drum	105.8
Bottom of same wagon	77
South center.....	79
Southwest corner, over office	79
Between steam-drums	80.1
Temperature of air outside in shade.....	64.4

At such a low temperature a *masse-cuite* poor in sucrose and boiled to string proof cannot crystallize to advantage.

Before beginning the experiments with sugar-cane about to be described I obtained permission of the company to provide a special hot room. With such material and with such unfavorable conditions of crystallization the yield of over 20 pounds of sugar per ton is a convincing proof of the efficiency of the process employed.

DISPOSITION OF THE EXHAUSTED CHIPS.

The problem of the disposition of the exhausted chips is one of great importance. By the failure of the machinery which was designed to re-

move the chips to a considerable distance from the building, the chips had to be taken away by scrapers. When it is remembered that these chips have slightly increased in weight in passing through the battery the great expense of this proceeding is at once apparent.

The percentage of water in the discharged chips was found to be as follows:

Number.	Per cent.	Number.	Per cent.
1.....	84.89	6.....	90.43
2.....	86.73	7.....	89.68
3.....	87.54	8.....	88.87
4.....	86.41	9.....	88.94
5.....	88.62	10.....	88.86
		Mean	88.097

Since the mean of former experiments shows that sorghum contains about 11 per cent fiber and matters insoluble in water, the composition of the waste chips as indicated by the above determination is:

	Per cent.
Fiber.....	11.00
Water.....	88.10
Other substances	.90
Total.....	100.00

After passing the waste chips through the mill they had the following per cent. of water:

Number.	Per cent.
1.....	66.57
2.....	63.74
3.....	63.06
4.....	67.73
Mean	65.28

At 70 per cent. extraction the bagasse therefore contains one part of fiber to two of water. By a short preliminary drying this bagasse would readily burn. At any rate it presses so readily, requiring so little power, that in my opinion, it would be a matter of economy to pass it through a three-roll mill.

The percentage of extraction obtained with the spent chips in small experimental mill will be seen by the following numbers:

The first column represents the per cents. calculated from weighing the bagasse and the second from weighing the expressed water:

Number.	From bagasse.	From water.
	Per cent.	Per cent.
1.....	73.06	79.65
2.....	72.16	68.31
3.....	80.00	64.85
4.....	72.80	69.20
5.....	70.80	65.33
Mean.....	73.70	69.17

Since it is difficult to accurately collect and weigh the fine bagasse which the spent chips afford, the mean of the second column will be found to represent more accurately the real extraction. It is certain that with a good three-roll mill each 100 pounds of the spent chips can be reduced to 30 pounds, one-third of which is combustible material. Even if no attempt is made to use the bagasse as a fuel the pressure is to be recommended on the score of economy. There appears to be no difficulty whatever in passing the chips through a three-roll mill, and their soft and pulpy state renders the pressure exceedingly easy.

Further reference to this point will be made in that part of the report devoted to sugar-cane.

THE CHARACTER OF THE CANE USED SEPTEMBER 27 TO OCTOBER 6, INCLUSIVE.

A considerable amount of interest has been excited by comparisons made of the cane worked during the time above mentioned and that used subsequently.

MILL JUICES.

The mill juices analyzed during this time had the following composition:

No.	Date.	Extraction.	Specific gravity.	Solids.	Sucrose.	Glucose.	Remarks.
		<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
106½	Sept. 28	53.00	1.0726	17.6	12.40	1.90	Cane from carrier.
112	Sept. 29	51.51	1.0684	16.6	10.41	4.08	Do.
119	Sept. 30	56.10	1.0764	17.8	12.39	3.76	Do.
126	Oct. 1	61.76	1.0634	15.5	8.37	4.95	Do. (stripped).
181	Oct. 2	.....	1.0842	20.2	14.50	1.77	Cane from carrier.
138	Oct. 3	54.54	1.0866	20.7	14.37	2.16	Cane brought in cars from Hammond.
147	Oct. 4	51.72	1.0680	16.6	10.50	2.60	Cane, amber, from carrier.
150	Oct. 4	51.35	1.0740	17.9	12.39	1.92	Cane, orange, from carrier.
159	Oct. 5	51.35	1.0710	17.2	10.65	3.27	Cane from carrier.
169	Oct. 5	56.00	1.0818	19.7	13.20	2.37	Cane, amber, on cars from Hammond.
170	Oct. 5	57.70	1.0778	18.8	9.95	4.88	Cane, orange, on cars from Hammond.
	Mean ...	54.50	.....	18.1	11.74	3.06	

No analyses were made on September 27 nor October 6.

	<i>Per cent.</i>
Mean purity of juice during time mentioned	64.8
* Mean purity of juice after October 6	49.7
Mean glucose per hundred sucrose during time mentioned	28.67
Mean glucose per hundred sucrose after October 6	54.68

* Total solids, 16.2 per cent.; sucrose, 8.05 per cent.; glucose, 4.41 per cent.

Diffusion juices.

Number.	Date.	Solids.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
108	Sept. 28	9.79	5.68	1.67
114	Sept. 29	12.4	6.76	2.92
118	Sept. 29	12.0	6.37	2.65
123	Sept. 30	14.4	7.22	4.16
128	Oct. 1	14.8	8.60	3.25
132	Oct. 2	13.7	7.01	3.32
133	Oct. 2	13.9	7.68	3.10
134	Oct. 2	13.2	7.18	2.75
139	Oct. 3	12.9	5.89	3.96
140	Oct. 3	12.7	6.51	3.65
141	Oct. 3	12.9	6.47	3.52
149	Oct. 4	9.8	4.10	2.38
152	Oct. 4	9.6	4.71	2.47
155	Oct. 4	11.5	5.42	3.28
160	Oct. 5	12.3	6.21	3.34
163	Oct. 5	13.0	6.44	3.58
166	Oct. 5	12.2	5.78	3.40
171	Oct. 5	12.2	6.03	3.23
Mean.....		12.4	6.04	3.15

Mean purity of juice during time mentioned	48.7
*Mean purity of juice after October 7	40.0
Mean glucose per hundred sucrose during time mentioned	52.13
Mean glucose per hundred sucrose after October 7	77.77

The mean purity of the mill juices during the interval named was 64.8 and of the diffusion juices 48.7, a loss of 16.1 points.

During the rest of the season the mean purity of the mill juices was 49.7 and of the diffusion juices 40.0, a loss of only 9.7 points.

The glucose per hundred of sucrose, during interval noted, in the mill juices was 26.07. In the diffusion juices it was 52.13, an increase of 26.06 points. During the rest of the season the glucose per hundred of sucrose in the mill juices was 54.68; in the diffusion juices 77.77; an increase of 23.09 points.

The most striking point about these comparisons during the interval named is the enormous difference between the mill juices and those of diffusion. In no other part of the season does the deterioration of the juice in the battery show itself to such an alarming extent.

There is only one explanation of this which appears satisfactory, and that is the fact that during this time the temperature of all the cells under pressure except the two central ones was kept within the limits of fermentation. The cane during this period, as a glance at the analyses will show, was by far the best worked during the entire season. The analyses of the chips made during this time shows the following mean results:

	Uncorrected.	Corrected.
	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose	8.41	8.82
Glucose	3.73	3.32

Corrected glucose per hundred of sucrose, 37.65.

* Total solids, 10.9 per cent.; sucrose, 4.36 per cent.; glucose, 3.44 per cent.

Thus, compared directly with the chips, the inversion in the battery was great.

Judged by the same standards, there was at no other time during the season so great an inversion of sucrose in the battery as during this period of few cells and low temperatures. Nevertheless the character of the cane was so good that the yield of sugar was large. Had, however, the cane been worked without the inversion spoken of, the yield of sugar would have been twice as large. During the same period the percentage of total sugars left in the exhausted chips was .80, while before this time it had only been .17.

It is therefore seen from the data given that the attempt to work the battery with few cells and at a low temperature increased the sugar left in the chips more than one-half, and caused a greater inversion of the sucrose than was experienced at any other time during the entire season.

I call especial attention to these facts, because during the period mentioned I was absent from Fort Scott. On my return I ordered the battery to be worked with nine or ten cells under pressure and at a uniform temperature of 70° C. This I believe to be the best method of operating a diffusion battery for sorghum, at least until some method is invented of distributing over the chips some substance which will neutralize the acids of the cane and thus entirely prevent inversion. The methods by which I attempted to accomplish this desirable result have already been described.

A further fact, which is illustrated by the analyses of the diffusion juices from uninjured canes, is that the diminished purity is produced solely by the extraction of gum and chlorophyll chiefly from the blades and sheaths, and that this injury can be avoided by a proper cleaning of the canes.

With clean canes and those in which the sucrose is still uninjured no alkaline substance will have to be used in the battery. When, however, deteriorated canes are used some such application will be necessary to save the sucrose from further inversion. As has already been pointed out, finely powdered lime or calcium carbonate evenly distributed over the chips offer the simplest solution of the difficulty.

MODIFICATION OF THE PROCESS OF CARBONATATION.

In order to avoid the discoloration of the sirup, which is the chief objection to carbonatation, the following modification of the process was adopted:

The juice used was obtained from sugar-cane sent from Fort Scott to Washington, and the experiments were made after my return from Kansas.

To the cane-juice was added 1 per cent. of its weight of freshly burned lime, and the carbonatation was continued until the juice was almost neutral. After raising to the boiling point to decompose sucro-carbon-

ates the juice was filtered, and then enough phosphoric acid added to precipitate the lime remaining in solution.

Since a slight excess of the acid will redissolve the precipitate and form acid phosphate, sodium phosphate was substituted for the phosphoric acid.

Much of the red color of the carbonatated juice was discharged by this process. After the precipitation was complete the juice was again boiled and filtered. It was then bleached with sulphurous acid and evaporated to 40° B.

In every instance the sirup made in this way was very light in color, perfectly transparent, and of the finest flavor. So pure was it, indeed, that it was found unnecessary to use any acetate of lead or any other defecating material to prepare this sirup for polarization. The quantity of phosphate of soda required to precipitate the lime in 5 liters of juice (11 pounds) was 100 cubic centimeters of a 10 per cent. solution. Therefore 10 grams of the sodium phosphate are sufficient for 5,000 grams of juice. About 4 pounds of sodium phosphate or 3 pounds of phosphoric acid would be sufficient for working a ton of cane.

The whole cost of treating cane juices with phosphoric acid or sodium phosphate will not be over 15 cents per ton of cane. The phosphoric acid, however, is not lost. It will reappear in the press cakes, having lost only half its value. Hence the actual cost of using this method of removing the lime is not probably over half of the estimate given above.

I made every effort to get phosphoric acid at Fort Scott, but could not succeed in time.

I believe the modification of the process here suggested will make a noted improvement in the molasses over any other procedure now in use.

GENERAL CONCLUSIONS.

In a general review of the work, the most important point suggested is the absolute failure of the experiments to demonstrate the commercial practicability of manufacturing sorghum sugar. The causes of this failure have been pointed out in the preceding pages, and it will only be necessary here to recapitulate them. They were:

(1) Defective machinery for cutting the canes and for elevating and cleaning the chips and for removing the exhausted chips.

(2) The deterioration of the cane due to much of it becoming over-ripe, but chiefly to the fact that much time would generally elapse after the canes were cut before they reached the diffusion battery. The heavy frost which came the 1st of October also injured the cane somewhat, but not until ten days or two weeks after it occurred.

(3) The deteriorated cane caused a considerable inversion of the sucrose in the battery, an inversion which was increased by the delay in furnishing chips, thus causing the chips in the battery to remain exposed under pressure for a much longer time than was necessary. The mean time required for diffusing one cell was twenty-one minutes, three times as long as it should have been.

(4) The process of carbonatation, as employed, secured a maximum yield of sugar, but failed to make a molasses which was marketable. This trouble arose from the small quantity of lime remaining in the filtered juices, causing a blackening of the sirup on concentration, and the failure of the cleaning apparatus to properly prepare the chips for diffusion.

A modification of the process which will prevent this trouble has already been explained; but, although an earnest attempt was made to introduce this method, it was found impossible to accomplish it before the end of the season.

I doubt whether any other industry has ever been the object of so much misrepresentation as this one.

In the preceding report I have endeavored to lay before you all the facts noted in the recent experiments. If I have not interpreted them correctly, I have, at least, given the data for a correct interpretation.

I should, indeed, be glad to leave this industry in a more promising condition. All admit that the process of diffusion has been successfully worked out, and to this opinion I subscribe, with the reservation that a proper mechanical method for distributing over the chips a substance to prevent inversion of the sucrose has not yet been discovered.

Honest differences of opinion still exist in respect of the best method of treating the diffusion juices, but it has been shown at Rio Grande that the diffusion juice from clean cane can be worked without any purification whatever.

Whether this purification is to be accomplished by carbonatation, filtering with brown coal, or in some other way, can easily be decided without menacing the future of the sorghum industry.

The problem of successfully cutting and cleaning the canes does not appear to me to be incapable of solution. It should have been solved the first thing, without leaving it for the last.

Last of all, the chief thing to be accomplished is the production of a sorghum plant containing a reasonably constant percentage of crystallizable sugar.

I cannot emphasize this point better than by quoting from some of my previous reports. In Bulletin No. 3, pp. 107-108, the following words are found:

IMPROVEMENT BY SEED SELECTION.

I am fully convinced that the Government should undertake the experiments which have in view the increase of the ratio of sucrose to the other substances in the juice. These experiments, to be valuable, must continue under proper scientific direction for a number of years. The cost will be so great that a private citizen will hardly be willing to undertake the expense.

The history of the improvement in the sugar-beet should be sufficient to encourage all similar efforts with sorghum.

The original forage beet, from which the sugar-beet has been developed, contained only 5 or 6 per cent. of sucrose. The sugar-beet will now average 10 per cent. of suc-

rose. It seems to me that a few years of careful selection may secure a similar improvement in sorghum.

It would be a long step toward the solution of the problem to secure a sorghum that would average, field with field, 12 percent. sucrose and only 2 per cent. of other sugars, and with such cane the great difficulty would be to make sirup and not sugar. Those varieties and individuals of each variety of cane which show the best analytical results should be carefully selected for seed, and this selection continued until accidental variations become hereditary qualities in harmony with the well-known principles of descent.

If these experiments in selection could be made in different parts of the country, and especially by the various agricultural stations and colleges, they would have additional value and force. In a country whose soil and climate are as diversified as in this, results obtained in one locality are not always reliable for another.

If some unity of action could in this way be established among those engaged in agricultural research, much time and labor would be saved and more valuable results be obtained.

In Bulletin No. 5, pp. 185-6-7, are found the following conclusions :

A careful study of the foregoing data will not fail to convince every candid investigator that the manufacture of sugar from sorghum has not yet proved financially successful.

The men who have put their money in these enterprises seem likely to lose it, and intending investors will carefully consider the facts herein set forth before making final arrangements. The expectations of the earlier advocates of the industry have not been met, and the predictions of enthusiastic prophets have not been verified. It would be unwise and unjust to conceal the facts that the future of the sorghum-sugar industry is somewhat doubtful. The unsatisfactory condition is due to many causes. In the first place, the difficulties inherent in the plant itself have been constantly undervalued. The success of the industry has been based on the belief of the production of sorghum with high percentages of sucrose and small amount of reducing sugar and other impurities.

But the universal experience of practical manufacturers shows that the average constitution of the sorghum-cane is far inferior to that just indicated. Taking the mean of several seasons as a sure basis of computation, it can now be said that the juices of sorghum as they come from the mill do not contain over 10 per cent. of sucrose, while the percentage of other solids in solution is at least 4.

It is needless to say to a practical sugar-maker that the working of such a juice is one of extreme difficulty, and the output of sugar necessarily small.

The working of sorghum juices will be found as difficult as those of beets, and true success cannot be hoped for until the processes used for the one are as complete and scientific as for the other. It is not meant by this that the processes and machinery are to be identical.

The chemical as well as mechanical treatment of the two kinds of juice will doubtless differ in many respects. And this leads to the consideration of the third difficulty, viz, the chemical treatment of sorghum juice. It has taken nearly three-quarters of a century to develop the chemistry of the beet-sugar process, and even now the progress in this direction is great. The chemistry of the sorghum-sugar process is scarcely yet a science. It is only an imitation of what has been done in other fields of work. Sorghum will have to develop a chemistry of its own. This will not be the work of a day or a year, but it will be accomplished sooner or later.

Careful study of climate and soil, joined with experience, will gradually locate those areas most favorable to the growth of this plant and its manufacture.

This is an all-important point in the problem, and is now occupying seriously the attention of the thoughtful advocates of the sorghum-sugar industry. One thing is already clear, i. e., that the area of successful sorghum culture is not nearly so extensive as it was thought to be a few years ago. I would urge a further investiga-

tion in this direction as a work peculiarly within the province of the Department, and one which would prove of immense benefit to the country. Five million acres of land, suitable to the purpose, will produce all the sugar required for this country for several years to come. It is therefore certain that the sugar industry will be confined to the most favorable localities. If a thorough, scientific study of all the soil and climatic conditions does not point out this region, bitter experience and the loss of hundreds of millions of dollars will gradually fix its boundaries. Last of all, the sorghum industry has suffered from the general depression which has been felt by the sugar industry of the entire world. Low prices have caused loss where every other condition has been favorable. It is hardly probable that the price of sugar will rise again to its maximum of the years passed. Only war, pestilence, or disaster would produce this effect. It is best, therefore, for the sugar-grower to accept the present price as final and make his arrangements accordingly. But low prices will produce increased consumption, and thus, even with a smaller profit, the sugar-grower, by increased production, may find his business reasonably remunerative, if not as enriching as before. The sorghum-sugar grower will be injured or benefited with the growers of other kinds of sugar by these economic forces. Hence there should be no enmity between the grower of the sorghum, the sugar-beet, and the sugar-cane, but all should work in harmony for the general good.

It is true the present outlook is discouraging. But discouragement is not defeat. The time has now come for solid, energetic work. Science and practice must join improved agriculture, and all together can accomplish what neither alone would ever be able to achieve. It is not wise to promise too much, but this Bureau would fall short of its duty were it either to suppress the discouraging reports of this industry or fail to recognize the possibility of its success. The future depends on the persistence and wisdom of the advocates of sorghum. The problem they have to solve is a most difficult one, but its solution is not impossible.

It must be confessed finally that the chief object of this last series of experiments, viz, to place the industry where private capital would see its way clear to its extension over a large area has not been attained.

It is now seen that much of what has been done is useless, and were the work to be gone over again these necessary mistakes of a first attempt would be avoided. Time, labor, and money could be saved.

What encouragement is just is offered to those who are willing to take up this work here and extend it.

The great difficulties in the way of extracting the sugar from the cane have been removed. The fact that sorghum, in certain circumstances, becomes a fine-sugar producing plant has been incontestably established. A suitable soil and climate have been found for growing the crop and manufacturing the sugar. Remaining difficulties in the way of success have been fairly and candidly pointed out.

Since the present appropriation was made for continuing and concluding these experiments, I consider that my connection with the development of the industry has ended. I leave the work with only one regret, and that is that the future of the sorghum-sugar industry is still in doubt.

EXPERIMENTS WITH SUGAR-CANE.

On the 1st of October I received instructions from you to purchase a few tons of sugar-cane in Louisiana and make some experiments with it at Fort Scott.

The managers of the Daily City Item newspaper of New Orleans, having learned of your intention, made arrangements with the Texas Pacific Railroad to transport this cane from Louisiana to Fort Scott for \$4 per ton. The general freight agent of the Mississippi Valley Railroad offered to deliver the cane on the same terms.

I requested Hon. Edward J. Gay to purchase the cane, which he kindly consented to do.

The cane was cut early in the season, viz, October 25 to 30, and was brought as quickly as possible to the factory.

PRELIMINARY TRIAL.

On November 2, three car-loads of cane having arrived, a preliminary trial was made.

The weight of cane used in this trial was 63.75 tons.

CUTTING-MACHINE.

The cutters which worked so poorly with sorghum did well with sugar cane, and no trouble whatever was experienced in producing chips suitable to diffusion and at the rate of six tons per hour.

CHIP ELEVATOR.

The same trouble was experienced with the elevator that we had had to contend with so long with sorghum, and to an increased extent. The chips being heavier than sorghum, easily overweighted the elevator and caused it to clog. Considerable delay was caused by these annoyances.

THE DIFFUSION.

It was found at once that the temperature used for the diffusion of sorghum, viz, 70° C., was entirely too low to effect the extraction of sugar from sugar-cane.

The temperature was gradually raised to 90° centigrade before a satisfactory extraction was obtained. The chips lying closer together in the cell caused the circulation of the liquid in the battery to take place

more slowly. It was clearly evident that the pressure afforded by the feed-tank of the battery, viz, two-thirds of an atmosphere, is not great enough to work a battery rapidly when twelve cells are under pressure.

ANALYSES OF THE CANES WORKED.

Samples of chips were taken from each cell until twelve were filled. These samples were then passed through a small mill and the juice obtained subjected to analysis.

The juices thus obtained had the following composition :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	14.6	10.52	2.22
Second sample	13.3	10.10	1.79
Third sample	14.6	10.89	2.08
Fourth sample	14.4	9.82	2.28
Fifth sample	14.4	10.04	2.02
Means	14.26	10.28	2.08

WEIGHT OF DIFFUSION JUICE.

From each cell were drawn off 1,000 liters of juice, or 1,040 kilograms.

The number of cells filled with chips was 60; the weight of each cell of chips was 2,125 pounds; weight of juice drawn off from each cell was 2,280 pounds, or 163 pounds more than the weight of cane used.

ANALYSES OF DIFFUSION JUICE.

The samples were taken from each charge of juice drawn. When twelve were taken the mixture was analyzed :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	7.2	5.01	1.15
Second sample	10.4	7.51	1.48
Third sample	10.8	7.72	1.56
Fourth sample	10.8	7.47	1.69
Fifth sample	11.3	7.73	1.77
Means	10.1	7.06	1.53

EXHAUSTED CHIPS.

Four samples of exhausted chips were taken. The first one was from the first five cells only. No samples were taken from the next nine cells, and after that the samples were taken regularly as before. Following are the analyses :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	3.5	2.34	.29
Second sample	2.1	.53	.12
Third sample	1.6	Lost.	Lost.
Fourth sample	1.8	.82	.18
Means	2.3	1.24	.20

The samples of carbonatated and sulphured juices were not taken with regularity. Nevertheless I give below their analyses:

CARBONATATED JUICES.

	Total solids.	Sucrose.	Glucose.
	Per cent.	Per cent.	Per cent.
First sample	7.0	4.57	.84
Second sample ...	11.1	8.05	1.20
Third sample	11.5	7.76	1.30
Fourth sample ...	10.2	7.70	1.32
Means	9.98	7.02	1.17

SULPHURED JUICES.

	Total solids.	Sucrose.	Glucose.
	Per cent.	Per cent.	Per cent.
First sample	6.7	4.48	.86
Second sample ...	11.0	8.12	1.30
Third sample	11.3	8.20	1.35
Fourth sample ...	11.0	8.60	1.36
Means	10.0	7.21	1.22

COMPOSITION OF SEMI-SIRUP FROM ABOVE JUICES.

	Per cent.
Total solids.....	55.4
Sucrose	43.3
Glucose.....	7.86

FIRST SUGARS MADE.

The *masse cuite* was put in cars on November 4 and stood four days before commencing to dry it.

It yielded of first sugars.....	pounds..	6,888
Of second sugars.....	do....	495

Total first and second sugarsdo.... 7,383

Sugar per ton.....	do....	115.8
Sugar on weight of cane	per cent..	5.79

PER CENT. OF TOTAL SUCROSE OBTAINED.

The expressed juice contained 10.28 per cent. sucrose. Reckoning the juice at 90 per cent. of the weight of the cane, gives percentage sucrose in cane	9.25
Per cent. sugar obtained	5.79
Per cent. of total sugar obtained	62.6

ANALYSIS OF FIRST SUGARS.

	Per cent.
Moisture	.95
Ash	.39
Glucose	1.05
Undetermined	.71
Sucrose	96.90

SECOND TRIAL.

On November 6, all the cane having arrived, the second trial was made. The experience of the first attempt had shown how the great loss of sugar in the chips, especially in the beginning, might be avoided. The second run was, therefore, made with an initial temperature of nearly 90° C. The quantity of juice withdrawn at each time was also increased by 100 liters.

Weight of cane used.—The weight of cane used in the second trial was 83.25 tons.

ANALYSES OF THE CANES.

The samples of chips were taken as described before :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	15.06	11.30	1.89
Second sample	14.68	10.86	1.62
Third sample	14.93	10.46	1.66
Fourth sample	13.47	10.43	1.89
Fifth sample	14.59	10.62	1.88
Sixth sample	13.55	10.05	1.75
Means	14.38	10.62	1.78

ANALYSES OF DIFFUSION JUICES.

The samples were taken as before described :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	10.11	7.33	1.18
Second sample	10.15	7.95	1.20
Third sample	10.08	7.15	1.17
Fourth sample	10.05	6.96	1.29
Fifth sample	9.83	7.03	1.29
Sixth sample	8.96	6.53	1.22
Means	9.86	7.16	1.23

EXHAUSTED CHIPS.

The samples were taken as described in the preliminary trial :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	1.56	.50	.12
Second sample	1.21	.38	.07
Third sample	1.11	.38	.10
Fourth sample	1.11	.37	.09
Fifth sample	1.06	.42	.10
Sixth sample	.77	.18	.05
Means	1.14	.37	.09

CARBONATATED JUICES.

The samples were taken in such a way as to represent the same body of juice corresponding to the same numbered samples of diffusion juice. Each carbonatation tank held three charges of diffusion juice. A measured sample after carbonatation was taken from each series of four tanks.

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample.....	10.11	7.27	1.09
Second sample.....	10.25	7.91	1.14
Third sample.....	10.14	7.25	1.11
Fourth sample.....	9.72	7.00	1.21
Fifth sample.....	9.72	7.10	1.22
Sixth sample.....	9.55	6.50	1.12
Means.....	9.92	7.17	1.15

SULPHURED JUICES.

The samples of sulphured juice were taken in a way to represent as nearly as possible the same body of juice as indicated by the corresponding numbers under carbonatated juice. Since, however, the juices after carbonatation had to fall into a receiving tank before being sent to the filter presses, some mixing of the different bodies of juice was unavoidable.

Thus the analyses below are not strictly comparable with the same numbers under diffusion and carbonatated juices :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample.....	9.88	7.68	1.09
Second sample.....	11.12	8.09	1.14
Third sample.....	10.35	7.39	1.23
Fourth sample.....	9.89	7.02	1.26
Fifth sample.....	10.15	6.98	1.28
Sixth sample.....	9.34	6.44	1.17
Means.....	10.12	7.18	1.20

SEMI-SIRUPS.

The semi-sirup from the above juices was put in two tanks. Samples were taken from each tank :

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample.....	42.9	32.0	5.95
Second sample.....	41.9	30.8	6.45

The first sample represents the first third of the run, and the second samples the second two-thirds.

FIRST SUGARS MADE.

The *masse-cuite* stood in cars two days.

On drying it yielded	pounds..	11, 185
The yield of "seconds" was	do...	805
Total weight produced	do...	11, 990
Sugar per ton	do...	144
Sugar to weight of cane	per cent..	7.2

PER CENT. TOTAL SUGAR OBTAINED.

	Per cent.
The juice contained	10. 62
And the cane	9. 56
Percentage sucrose obtained	75. 3

COMPOSITION OF THE FIRST SUGARS.

The sample was taken from each barrel as it was filled. The samples were all mixed well together and placed in a tight bottle, which was not opened until the sample for analysis was taken. It is, therefore, as fair a sample of the product made as could possibly be obtained. It gave of—

	Per cent.
Moisture	.73
Ash	.14
Glucose	.52
Undetermined	.61
Sucrose	98. 00

Compare this result with the work on Magnolia plantation last year, as found in Bulletin No. 11, p. 26 :

	Pounds.
Weight first sugars per ton	119
Weight second sugars per ton	29. 75
Total first and second	148. 75
	Per cent.
Percentage obtained	7. 44
Sucrose in juice	12. 11
Sucrose in cane	10. 90
Percentage obtained	68. 3
Sucrose in cane at Magnolia	10. 90
Sucrose in cane at Fort Scott	9. 56
Difference	1. 34

The increase in the yield per ton at Magnolia, had the cane been worked by diffusion, would have been, therefore, 26.8 pounds.

The yield of seconds at Fort Scott was surprisingly low. The molasses as it came from the centrifugals was full of crystals. About one-third its volume of warm water was added to this molasses and the crystals all dissolved before boiling. This may have diminished the yield.

The "thirds" have been placed in cars and set away until next fall.

The "thirds" fill five wagons, each containing 23 cubic feet, or in all 125 cubic feet, weighing approximately 10,000 pounds. Of this amount, 6,189 pounds are from the second run.

	Pounds.
The total product, therefore, is, sugar	11,990
Thirds, <i>masse cuite</i>	6,189
Total	18,179

Or 218.3 pounds per ton of cane worked. This is nearly 11 per cent. of the weight of cane used.

But calculated on the original *masse cuite*, which filled 9 cars, there would have been $9 \times 23 = 207$ cubic feet, or 18,837 pounds = 226 pounds per ton, or 11.3 per cent.

But the method of reckoning the increased production which has just been used is not a fair one, since it rests on the assumption that the sucrose in each case is equally available. But a moment's consideration will show that this is not the case.

The term "available sugar" is not a precise one. It may have many interpretations. In France, for instance, the *rendement* is calculated by deducting from the total sucrose twice the glucose and from three to five times the ash. This is a good rule for beet sugar, but in cane-juice the ash, being mostly calcium salts, is far less melassigenic than that of the beet-juice, made up chiefly of potassium compounds.

Another method of calculating "available sugar" is to diminish the percentage of sucrose by the difference between it and all the other solids in solution. This method is apt, however, to give results too low. In this uncertainty the term "available sugar" should always be accompanied by an explanation of the manner of making the calculation.

The yield of sugar obtained at Fort Scott, being the highest ever got from sugar-cane, may be taken as the true amount of "available sugar" until some better yields are reported.

Notice, for a moment, the relation of this yield to the respective quantities of sucrose and glucose present:

	Per cent.
Sucrose in juice	10.62
Sucrose in cane	9.56
Yield of sucrose	7.20
Difference between sucrose in cane and yield	2.36
Glucose in juice	1.78
Glucose in cane	1.60

Ratio of per cent. of glucose to per cent. of sucrose lost 1.5 nearly.

It appears, therefore, that the rational way to calculate "available sugar" when the quantities of sucrose and glucose in the canes are known is to diminish the percentage of sucrose by one and a half times the glucose.

Applying this method we have the following results:

AT FORT SCOTT.

Sucrose in cane	per cent..	9.56
One and a half times glucose in cane	do....	2.40
Theoretical available sugar	do....	7.16
Pounds per ton		143.2
Pounds per ton obtained		144

AT MAGNOLIA.

Sucrose in cane	per cent..	10.90
One and a half times glucose in cane	do....	1.38
Theoretical available sugar	do....	9.52
Pounds per ton		194.4
Pounds per ton obtained		148.75
Difference	pounds..	41.65

This shows in the most convincing manner that by the process of diffusion and carbonatation the yield of sugar from sugar-cane can be increased fully 30 per cent. over the best milling and subsequent treatment of the juice which has ever been practiced in this or in any other country.

If this be true of the best milling, it is easy to estimate the increase over the average milling of Louisiana. It is not extravagant to suppose that this increase will be fully 40 per cent.

But the problem may also be approached in another way. It has just been shown what the product would have been had the Fort Scott process been applied at Magnolia. It may now be asked, "What would have been the yield had the Magnolia process been applied at Fort Scott?"

The process used at Magnolia produced 148.75 pounds sugar from cane in which the available sugar was 190.4 pounds. The percentage of available sugar obtained was

$$148.75 \times 100 \div 190.4 = 78.1 \text{ per cent.}$$

The available sugar in the cane at Fort Scott was 7.16 per cent. Multiply this by .78 and the product, 5.58 will be the yield of sugar which the Magnolia process would have given at Fort Scott, or 111.6 pounds per ton. Deduct this from the quantity obtained and the remainder will represent the increased yield, viz, 32.4 pounds. Thus in whatever way the calculation is made it is seen that the processes of diffusion and carbonatation give a largely increased yield.

Another important question which arises is this, "Does this increased yield come wholly from the increased extraction, or is it partly due to the method of purifying the juice?" I will try to give a rational answer to this question based on the data of the analyses and the respective *rendements* given by the two processes.

The percentage of extraction at Magnolia was 78. Reckoning the

juice at 90 per cent., the loss in juice was 12 per cent. The percentage of juice, and consequently of sugar extracted, was 86.6 per cent. The mean loss of sugar in the chips at Fort Scott was .38 per cent., and the quantity of sugar present was 9.56. The percentage of extraction was therefore 96 per cent. The gain in extraction by diffusion is therefore 9.4 per cent. It is thus evident that the large gain in yield, as established at Fort Scott, cannot be due wholly to the increased extraction of the sugar. It must therefore be largely due to the processes of depuration employed.

The process of carbonatation tends to increase the yield of sugar in three ways:

(1) It diminishes the content of glucose. This diminution is small when the cold carbonatation as practised at Fort Scott is used; yet, to at least once and a half its extent, it increases the yield of crystallized sugar.

(2) By the careful use of the process of carbonatation there is scarcely any loss of sugar. The only place where there can be any loss at all is in the press cakes, and when the desucration of these is properly attended to the total loss is trifling. The wasteful process of "skimming" is entirely abolished, and the increased yield is due to no mean extent to this truly economical proceeding.

(3) In addition to the two causes of increase already noted, and which are not sufficient to produce the large *rendement* obtained, must be mentioned a third, the action of the excess of lime and its precipitation by carbonic acid on the substances in the juice, which are truly melassigenic. Fully half of the total increase which the experiments have demonstrated is due to this cause. It is true the coefficient of purity of the juice does not seem to be much affected by the process, but it is evident that the treatment to which the juice is subjected increases in a marked degree the ability of the sugar to crystallize. This fact is most abundantly illustrated by the results obtained.

Not only this but it is also evident that the proportion of first sugars to all others is largely increased by this method. This is a fact which may prove of considerable economic importance.

It thus appears that the yield of sugar would be greatly increased by the application of carbonatation to mill juices. Since a complete carbonatation outfit can be erected for about \$4,000 it would be well if some planter or syndicate of planters should give the process a trial.

These facts are worthy of closer consideration, inasmuch as the process of carbonatation has been fiercely and maliciously assailed as one which destroys both sugar and molasses.

WEIGHT OF DIFFUSION JUICE COMPARED WITH WEIGHT OF CANE WORKED.

Number of cells filled, 86.

Weight chips in each cell = $86 \div 83.25 = 1.033$ tons = 2,066 pounds.

Weight juice drawn from each cell of chips 1,100 liters. Specific gravity 1.04 = 2,516.8 pounds.

The weight of normal juice in 2,066 pounds of cane is 1,859.4 pounds. The additional weight of water added by diffusion is 657.4 pounds.

The percentage of increase over normal juice $657.4 \div 1,859.4 = 35.4$ per cent. This increase represents what is often called the "dilution" of the juice. The quantity of water to be evaporated to produce a given quantity of sugar is, therefore, 35.4 per cent. greater for such a diffusion than for a normal mill juice. In practice this amount could easily be reduced to 25 per cent.

COMPOSITION OF PRESS CAKE.

The defecation and filtration of the juice from 83.25 tons of cane gave 197 press cakes.

The mean weight of these cakes was 24 pounds each, and the total weight 4,728 pounds. A sample of the cake taken directly from the press and dried contained of moisture 45.37 per cent. The total weight of dry matter obtained in the press cakes was, therefore, 2,582.9 pounds.

Analyses of the dried cake gave the following results:

	Per cent.
Albuminoids	9.585
Sucrose	Trace.
Glucose	Trace.
Other organic matter	17.45

QUANTITY OF LIME USED.

As is seen under sorghum experiments it required 1.5 per cent. lime to produce a good filtration.

I felt sure that the juice from the sugar-cane would not require as great a quantity. At the preliminary trial 1 per cent. of lime was used and the cakes formed were perfect, firm, and hard.

In the second run only .75 per cent. of lime was used, and the cakes were equally as good. There is little occasion for using less lime than this, for with this quantity the carbonatations were easily finished in fifteen to twenty minutes.

COEFFICIENT OF PURITY IN SECOND TRIAL.

	Per cent.
Of the mill juices the coefficient was	73.8
Of the diffusion juices the coefficient was	72.6
Of the carbonatated juices the coefficient was	72.3
Of the sulphured juices the coefficient was	70.9
Of the first semi-sirup the coefficient was	74.6
Of the second semi-sirup the coefficient was	73.5

In both trials it was seen that the coefficient of purity was increased during the process of evaporation. This was, doubtless, caused by the precipitation of some of the lime salts held in solution by the juices.

DEGREE OF EXTRACTION BY EXPERIMENTAL MILL.

	Fresh chips per cent. juice ob- tained.	Exhausted chips per cent. water extracted.
First sample.....	54.64	63.73
Second sample ..	58.88	62.68
Third sample.....	57.61	63.39
Fourth sample....	55.85	62.01
Fifth sample	60.00	60.65
Sixth sample.....	51.48	60.88
Mean.....	56.41	63.72

DIFFICULTIES ENCOUNTERED.

A number of unfavorable conditions was encountered during the prosecution of the experiments. The water supply was from a stagnant pond. The water had been greatly improved by the application of lime a few days before the experiment was made, but it was still black and putrid, emitting a nauseating stench.

The strike-pan used was quite unsuitable for boiling to grain. Its base was once the bottom of a much smaller pan, and a shelf several inches deep had been added to support the enlarged top. All the large steam-coils were above this shelf, and it took eight hours to bring the contents of the pan above this point. We had no sugar-boiler, but my assistant, Mr. G. L. Spencer, took charge of the pan and did remarkably well.

The sugar dried slowly in the centrifugals. These were not well set and could not be run at a very high speed on account of shaking.

It took nearly forty-eight hours with three machines to dry the sugar from the 83.25 tons.

This difficulty in drying was due either—

(1) To the process of diffusion; (2) to the process of carbonatation; (3) to the fine grain produced in boiling; (4) or to the poor quality of the cane.

Which one of these causes was most potent only future experiments will decide. I am not wise enough to place it, as has already been done by some premature critics, on one of them alone.

It seems most reasonable to suppose, however, that the poor quality of the cane and the extreme fineness of the crystals were the chief causes of the difficulty mentioned. The process of carbonatation has been practiced for ten years in Java on mill juices and no complaint has ever been heard of difficulty in purging the sugar. With the fresh, ripe canes of Louisiana worked promptly as they come from the field, and with the juice in the hands of an experienced sugar-boiler, I do not believe this difficulty would be encountered.

With the improvements in the process of carbonatation already pointed out in the discussion of the experiments with sorghum even better results may be expected.

BAGASSE.

The disposition of the exhausted chips is a question of great economic importance. Three uses appear to be possible : (1) For paper stock ; (2) for manure ; (3) for fuel.

A good article of both wrapping and print paper can be made of the fiber of the cane. The economic discussion of this use, however, can only be properly given by a paper-maker.

The value of the bagasse for a manure is undoubtedly great. This problem has already been discussed in Bulletin No. 8, page 46.

By referring to the table of analyses of the chips it will be seen that with a small hand-mill 63.72 per cent. of water was extracted from the exhausted chips; on the same mill the percentage of extraction of the fresh chips was only 56.31 per cent. Thus in similar conditions the percentage of extraction with a given mill will be 7.31 per cent. higher for exhausted chips than for fresh canes. A mill, therefore, which will give a 78 per cent. extraction with cane will give 85 per cent. with exhausted chips.

The exhausted chips contained 90 per cent. water. Of this quantity 63.72 per cent. were extracted, leaving 26.28 per cent. water to 10 fiber.

A given quantity of the bagasse, therefore, contained 72.2 per cent. water and 27.8 per cent. fiber. A mill which would give 80 per cent. extraction with the exhausted chips would furnish a bagasse composed of equal parts of water and fiber and this would prove a most excellent fuel.

The power required to drive such a mill would only be about one-third as great as for the same weight of cane.

The attempts to dry cane chips on the presses used for beet cuttings have proved failures, but the experiments made at Fort Scott show that a properly arranged mill will solve this problem at once.

It must be remembered, however, that even if the exhausted chips be made as dry as ordinary mill bagasse they will not afford so much fuel. They contain little but the fiber of the cane, while mill bagasse still holds large quantities of sugar, which itself is a most excellent fuel.

The loss of the bagasse as a fuel has been the principal objection to the introduction of diffusion into tropical sugar districts.

It now remains to continue these experiments at some favorable station in Louisiana. Such a station should be provided with a first-class double or triple effect and other apparatus for evaporating the juice and separating the sugar.

It should also be a station purely experimental. The attempt to carry on experiments and manufacture a large crop of cane at the same time would only end in the disastrous manner, economically considered, of the sorghum work just concluded at Fort Scott.

These experiments can only be successful at a station where perfect freedom of action and plenty of time are at the director's command.

It is the proper province of the Department to demonstrate in Louisiana just how much increase in sugar yield can be produced by the application of the methods named in the act making the appropriations. This done, and all the processes for doing it accurately pointed out and logically discussed, it will not be difficult for the intelligent planter to determine the economic value of the new methods.

To this task should be brought a careful study of the chemical problems involved, and the best apparatus which this country or Europe can afford. From this task should be eliminated all prejudices for or against any particular process, and especially all tendency to misrepresent or misinterpret facts.

At least the Department will be able in subsequent experiments to show the Southern sugar-raiser whether the promises which these preliminary experiments have made shall really be performed, or whether the practice of the process of diffusion for sugar-cane is a mistake and the prospects it has offered of aiding the sugar industry a delusion.

It is certain that with the fierce rivalry between the European beet and the tropical cane industry, producing an enormous surplus of sugar and sending the prices down almost below the cost of production, the indigenous sugar-cane industry of this country will languish unless the Department of Agriculture be able to lead it into a life of renewed vigor.

INDEX.

	Page.
A.	
Acidity in battery, correction of.....	28
chips	22
juices	22
Albumen, coagulation of	29
Analyses of burnt lime.....	14
carbonated juices before October 1.....	19
after September 30	19
carbonated juices	49
chips, first season to October 1.....	16
from October 1 to close	16
chips in closed bottles.....	26
chips exhausted in bottles, with and without neutralizing	17
diffusion juice.....	46
diffusion juices.....	48
to October 1	18
October 1 to close	18, 19
exhausted chips.....	46, 48
first sugars	50
gases, by G. L. Spencer	13
juice from chips.....	31
juice of chips from cutters.....	17
limestone	14
masse-cuite	22
mill juices before October 1	15
after September 30	15, 16
molasses	22
press cakes	23
semi-sirups	21, 47, 49
slag	14
spent bone-black	14
sulphur juices before October 1	19
after September 30.....	20
sulphured juices	47, 49
waste chips before October 1.....	21
after September 30	21
waste waters before October 1	20
after September 30.....	20
Analysis of first sugars	47
sample sugar	22
Appropriation	6
Available sugar, meaning of.....	51
calculation of	51

	Page.
B.	
Bagasse, disposition of	56
moisture in	23
Battery, acidity in, correction of	28
inversion in	26
pressure in	46
Beet-root cutter	9
Belle City ensilage cutter, description of	10
Blades, per cent. of	35, 36
Brown coal, filtration with	42
Bulletin No. 3, quotation from	42
No. 5, quotation from	43
No. 8, reference to	56
No. 11, quotation from	32, 50
Burnt lime, analyses of	14
C.	
Canes, analyses of	46, 48
character of, September 27 to October 6, inclusive	38
cleaning of	10
delay in working	26
delivery to cutters	12
deterioration of	41
used, weight of	48
Cane-cutters, description of	9
conclusions from experiments with	10
cutter, centrifugal, description of	10
Carbon dioxide, percentage of, in the gas	24
reduction of	24
Carbonic oxide, formation of	24
odor of	24
toxic effect of	24
Carbonate of lime, use of, in battery	28
Carbonatation apparatus	12
proposals for	8
cost of	53
employment of	42
experiments with double	25
increase of yield by	53
modification of	40, 41
yield of crystallizable sugar by	33
tanks	13
Carbonatated juices, analyses of	47, 49
before October 1	19
after September 30	19
ratio sucrose to glucose in	33
Cells, number of cut	35
Centrifugals	55
Chips, analyses of, from first season to October 1	16
October 1 to close	16
in closed bottles	26
juice from	31
acidity in	22
direct estimation of sugar in	27
direct extraction of	26

	Page.
Chips, exhausted in bottles, with and without neutralizing, analyses of	17
from cutters, analyses of juice of	17
glucose, per hundred, sucrose in	31
moisture in	23
purity of	31
removal of	11
sampling of	31
total solids in	30, 31
weight of, in each cell	35, 53
Climate and soil, study of	43
Closed bottles, inversion in	26
Comparison of results at Fort Scott and Magnolia	52
Competition of beet-sugar with cane-sugar	57
Colwell Iron Company	9
Crampton, Dr. C. A., analyses by	13
Crystallization, unfavorable condition of	36
Crystallizing room, temperature of	36

D.

Data, discussion of	24
general review of	32
Defective machinery	41
Delivering chips to battery, apparatus for	11
Diffusion, fermentation during	9
temperature of	9, 45
time of	9, 41
battery, description of	8
cell, capacity of	9
juice, analyses of	46
juices, analyses of	48
to October 1, analyses of	18
October 1 to close, analyses of	18, 19
September 27 to October 6 inclusive	30
juice, treatment of, at Rio Grande	42
juices, ratio sucrose to glucose in	32
juice, weight of	46, 54
Difficulties encountered	55
Dilution, percentage of	54
Drying the sugar, difficulty of	55

E.

Exhausted chips, analyses of	46, 48
disposition of	36, 37
drying of	56
percentage of sugar in	34
water in	37
Experiments, continuance of	6
in Louisiana, proper functions of	57
Extraction in closed bottles, errors of	27, 28
degree of, by experimental mill	55

F.

Fake, N. J., analyses by	13
Filter presses	13

First sugars, analysis of.....	47
analyses of.....	50
made, weight of.....	50
Fives-Lille Company, drawings of.....	9
Fort Scott Foundry.....	10

G

Gas, analyses of.....	13
supply of.....	12
volume of, employed.....	25
Gay, Hon. Edward J.....	45
General conclusions.....	44
Glucose, percentage of, diminished by 9.....	29

H.

Halleesche Maschinenfabrik.....	12
Handling cane, machinery for.....	12
Horizontal cutter, capacity of.....	10
Hughes, H. A., cane-cutter of.....	9

I.

Inversion, avoidance of, in battery.....	32
Item, Daily City.....	45

J.

Juices, acidity in.....	22
-------------------------	----

K.

Kroog, filter-press of.....	13
-----------------------------	----

L.

Letter of transmission.....	4
Lime, quantity of, used.....	54
bisulphite, use of, in battery.....	28
acetate, formation of.....	29
water, use of, in battery.....	28
Lime juice, use of, in battery.....	28
Lime-kiln, working of.....	12
Limestone, importance of good quality.....	24
quantity and quality of.....	12
Limestones, analyses of.....	14
Louisiana Station, apparatus for.....	56

M.

Machinery, contract for.....	6
Magnolia plantation, comparison with.....	50
station at.....	32
Masse-cuites, analyses of.....	22
total weight of.....	51
Melada, weight of, obtained.....	36
Mill juices, variations in.....	25
glucose, per hundred, sucrose in.....	26
analyses of, before October 1.....	15
after September 30.....	15, 16

Mill juices, index to.....	Page. 15, 16
September 27 to October 6, inclusive.....	38
Moisture in chips and bagasse.....	23
Molasses, analyses of.....	23
character of.....	36

P.

Parkinson, W. L. apparatus designed by.....	12
Sugar Company, agreement with.....	5
Phosphoric acid, use of.....	41
Portland Beet Sugar Company.....	9, 12
Preliminary trial.....	45
Press cakes, analyses of.....	23
composition of.....	54
organic matter of.....	24
moisture in.....	23
total sugar in.....	34, 35
value as a fertilizer.....	35
weight of.....	23
Proposals of Pusey & Jones Company, acceptance of.....	7
Pump.....	12
Purity, coefficient of.....	54
Pusey & Jones Company.....	13
contract with.....	6
proposals of.....	7

R.

Railroad, Mississippi Valley.....	45
Texas Pacific.....	45

S.

Sample sugar, analysis of.....	22
Sangerhauser Maschinenfabrik.....	13
Second trial.....	48
Semi-sirups, analyses of.....	21, 47, 49
Sheaths, per cent. of.....	35, 36
Slag, analyses of.....	14
Sodium phosphate, use of.....	41
Sorghum, ease of diffusion of.....	34
insoluble matter in.....	37
improvement of.....	42, 43
cane, character of, at Fort Scott.....	32
juice, chemical treatment of.....	43
Spencer, G. L.....	12, 13
analyses of gases by.....	13
Spent bone-black, analyses of.....	14
Strike-pan, construction of.....	55
Sucrose obtained, total per cent. of.....	47
inversion of, in the battery.....	40
inversion of.....	30
Sugar, total yield of.....	36
per ton, weight of.....	50
obtained, total per cent. of.....	50
Sugars made, weight of.....	47

	Page.
Sugar-cane, experiments with	45
Sugar, direct estimation of, in chips	27
character of	36
available in cane	31, 32
Sulphur apparatus	13
working of	13
juices before October 1, analyses of	19
after September 30, analyses of	20
Sulphured juices, analyses of	47, 49
ratio sucrose to glucose in	33
Sulphurous acid, replacement of, by phosphoric	34
Swenson, Prof. M., filter-press of	13
suggestion of	28

T.

Tops, per cent. of	35, 36
--------------------------	--------

W.

Waste chips before October 1, analyses of	21
after September 30, analyses of	21
composition of	37
percentage of water in, after pressure	37
Waste waters before October 1, analyses of	20
after September 30, analyses of	20
percentage of sugar in	34
Water supply, character of	55
Work, results of	35

Y.

Yield, increase of	52
--------------------------	----



U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 15

REPORT

OF

EXPERIMENTS IN THE MANUFACTURE OF SUGAR

AT

MAGNOLIA STATION, LAWRENCE, LA.,

SEASON OF 1886-1887.

THIRD REPORT,

BY

GUILFORD L. SPENCER.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1887.

19023—No. 15

LETTERS OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., April 12, 1887.

SIR: I have the honor to submit herewith for your inspection and approval the results of the experimental work carried on by your direction in Louisiana during the manufacturing season of 1886 by Mr. G. L. Spencer, assistant in the Division of Chemistry.

The information collected is of the highest interest to Louisiana sugar growers, and is made still more valuable by some comparative studies of the Cuban sugar industry.

Very respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., March 31, 1887.

SIR: I have the honor to submit the third report of the Department's experiment station at Magnolia plantation.

Included in this report is a brief statement of the work of three Cuban sugar-houses, indicating certain economies that it would be well for the planters of this country to adopt.

Accompanying this report is an article on sugar analysis, prepared at my request by Dr. C. A. Crampton. This contains a valuable table, devised by Dr. Crampton some years since, and which is now employed at the Department's stations for the calculation of analyses.

Very respectfully,

G. L. SPENCER,
Assistant Chemist.

Dr. H. W. WILEY,
Chemist.

EXPERIMENTS IN THE MANUFACTURE OF SUGAR.

The manufacturing season at Magnolia commenced November 7, 1886, and ended December 20. This completes the third season's work of the Department at this station.

I shall give, in as few words as possible, a comparison of the growing seasons of the past three years.

In 1884 the weather was favorable until the 1st of June, then followed a period of very wet weather, lasting until August, which was a very dry month. The conditions in September and October were favorable to the ripening of the cane. During the rolling season there were frequent and heavy rains.

Season of 1885.—The early part of this season was exceptionally wet. From April to July the rainfall was limited to but three or four showers; in August and September the rains were frequent and heavy; in October and the rest of the season the weather was exceptionally dry and cool, the mean temperature being considerably below that of 1884. The cane was prostrated in September by a heavy wind storm.

Season of 1886.—In consequence of cold, wet weather in February, March, and April the cane obtained a very late start. May was dry and cool; June and July were so wet that it was impossible to properly cultivate the cane; August was dry and exceedingly hot. In September, October, and the rolling season the weather was very dry. The drought probably saved the cane from damage in the heavy wind storm of October, when the lower coast of the Mississippi near Pointe à la Hâche was seriously damaged. There was a killing freeze November 17. This is the earliest freeze, with one exception, noted in the plantation records, extending over a long period of years. December was cold.

It may be seen from the above statements that these three seasons differed very materially from one another. That of 1884 might be considered very favorable. The tonnage was fair and the cane rich. In 1885 the conditions were also favorable, with the exception of the wet weather in September and the heavy wind storm. The tonnage was large, but the quality of the cane was poor.

In January, 1886, there was a severe freeze, perhaps the most severe on record in Louisiana. At the time of this freeze it was feared that

the stubble had been damaged by the frost, but such did not prove to be the case.

It is customary at Magnolia to burn the trash in the fields soon after the cane is all harvested. There is a general impression among planters that this exposes the stubble to danger from frost. The experience of the past season at Magnolia demonstrates that such is not the case.

The tonnage this season has been unusually small, but the cane has been a little richer in available sucrose than any time since the station was established.

In comparing the work of the sugar-house it is probably better to compare this season's work with that of 1884-'85. The same grades of sugar were made these seasons.

The yield per acre in 1885-'86 was 2,988 pounds of first, second, and third sugars. In 1886 the yield, first and second sugars, was 1,964 pounds. A decrease of 6.66 tons of cane per acre resulted in a decrease of 1,024 pounds of sugar.

The yield of sugar per ton of cane the past season has been exceedingly satisfactory, but nevertheless it is expected that a few changes in the house will materially increase the output of sugar.

This season only two sugars were made. The first graded "Choice off white." The yield of first sugar would have been larger had it been possible to boil the *masse cuite* stiffer, but the strike valve of the pan would not admit of doing so. As large a proportion of the sugar as possible should be obtained in the firsts, not only on account of the higher price of this grade of sugar, but because less sugar is left to be reboiled for lower grades and consequently the loss from inversion is diminished.

Since most of the sugars and molasses in Louisiana are made to enter directly into consumption, the planter is compelled to lime the juice lower and boil hotter than he would otherwise. Were it practicable by present methods to work alkaline the loss from inversion even at high temperatures would be greatly diminished.

I have examined beet molasses from sugars boiled with a vacuum of less than 24 inches that contained but little more than a trace of invert sugar. The clarified juices and sirups were always worked alkaline.

IMPROVEMENTS IN THE SUGAR-HOUSE AND THE PLANTATION.

Very few changes were made in the house preparatory to this season's work, and those only for the improvement of the work of machinery already in place.

The tanks for skimmings were provided with a better arrangement for decanting the clear juice. The lowest outlets from these tanks are about 2 inches above the bottoms. Outlets should be provided so located that the tanks could be drained, effecting a large saving in sugar.

It is not necessary to wash these tanks very often. The wash-out valve should be out of the control of the filter-press man. These tanks should not be encumbered with coils, but should have double bottoms, that they may be easily discharged and washed.

Perhaps the most important improvement this season was in the work of the double effect. The substitution of a larger sweet-water pump enabled it to concentrate all the juice and obviated the necessity of employing an open pan as last season.

Among other improvements in progress at Magnolia is the introduction of tile drainage. Lines of tile will be laid 30 feet apart, running from the front or river to the rear or marsh side of the plantation. The ditches will be dug by machinery; 3-inch, 4-inch, 5-inch, and 6-inch tiles will be used.

Governor Warmoth intends draining 1,000 acres of land. This drainage system will necessitate an expenditure of about \$12,000.

Aside from benefits to be derived from better drainage there will be important advantages gained from closing the ditches. The amount of tillable land will be increased about 70 acres; the large annual expenditure for keeping the ditches and quarter-drains open will be stopped; the cultivation will be easier and less expensive, and the steam plows can be handled more advantageously.

Should the work of this station be continued very interesting and valuable data can be obtained.

ACCIDENTS TO THE MILLS.

The mills were stopped several times by small pieces of iron. Some of this iron passed through the shredder; other pieces must have been introduced after the cane left the shredder. It was evident that this iron was put on the carrier maliciously. This trouble finally culminated in the breaking of the shell of one of the rolls of the supplemental mill. A few changes were made in the disposition of the laborers detailed for work about the mills, and the rolling was finished without further accident than the breaking of three couplings.

The average extraction and consequently the yield of sugar would have been larger had the supplemental mill not have been damaged.

THE BAGASSE-BURNER.

The burner,¹ as improved last season, continued to work satisfactorily. The consumption of coal was materially reduced.

CONSUMPTION OF FUEL.

The amount of coal consumed was determined as follows:

The coal was weighed for half the season and the total consumption was based on the data obtained.

¹Chem. Bulletin No. 11, p. 6.

Pounds of coal consumed in twenty-one days, 436,338; average of 20,778 pounds per day. From the time the fires were kindled until the work was entirely finished was forty-five days, hence the total consumption was $45 \times 20,778 = 935,010$ pounds. The total quantity of sugar made was 1,159,768 pounds, therefore the consumption of coal per 1,000 pounds of sugar was 906 pounds or 4.42 barrels. These figures do not include the coal used in the revivification of the char.

This house could be worked almost entirely without coal if the following improvements were made:

(1) Substitute copper coils for the iron ones now in use in the clarifiers.

(2) Discontinue the practice of clarifying the juice after defecation.

(3) Introduce a condenser employing juice to condense the vapors from the double effect. An illustration of such apparatus is given opposite page 114, Chem. Bulletin No. 5, and is there termed a *Calorisateur à contre-courant*.

(4) Substitute a low-pressure vacuum-pan for the one now in use.

Under these conditions the juice-heater described in last year's¹ report would not be necessary. It could probably be converted into a condenser.

The question of economical engines is of not so great importance, since the exhaust steam is employed for evaporation.

COMPOSITION OF THE JUICE.

The chemical work this season at Magnolia Station was not begun until the 24th of November. Although the work of the sugar-house nominally commenced November 7th, but very little cane was rolled before the 13th. The analyses, therefore, show the composition of the juice for all but eleven days of the season; in which time 2,113 tons of cane were rolled. The cane yielded 8 pounds less sugar per ton than the next 2,000 tons, consequently it is fair to presume that it contained less sucrose.

¹ Chem. Bulletin No. 11, page 8.

TABLE I.—Composition of the raw juices.

[When two analyses are given the same date the first was sampled in the morning, the second in the afternoon.]

Date.	Numbers.	Degree Baumé.	Degree Brix (per cent. total solids.)	Specific gravity.	Sucrose.	Reducing sugars.	Albuminoids.	Albuminoids per cent. sucrose.	Coefficient of purity.
Nov. 24	1	9.4	17.00	1.0700	Per cent. 13.50	Per cent. 57	Per cent. 2438	1.80	79.41
25	2	9.0	16.80	1.0669	12.84	.06	2003	1.61	78.77
25	3	9.2	16.96	1.0682	13.90	.82	.0625	.45	88.48
26	4	8.6	15.56	1.0634	12.28	.57	.1625	1.32	78.97
26	5	9.1	16.37	1.0674	13.00	.74	.0875	.64	88.08
27	6	8.6	15.55	1.0634	12.00	.73	.2250	1.88	77.17
28	7	8.5	17.21	1.0709	14.36	.46	.1500	1.04	83.43
28	8	8.9	17.07	1.0704	14.21	.49	.1625	1.14	83.24
29	9	8.9	17.88	1.0739	15.04	.43	.1875	.91	84.11
30	10	8.6	17.33	1.0713	14.54	.53	.....	.....	83.90
30	11	8.4	16.90	1.0695	13.91	.46	.1188	.85	82.30
Dec. 1	12	8.2	16.69	1.0687	14.21	.39	.....	.....	85.14
1	13	9.5	17.16	1.0709	13.95	.68	.1875	.99	81.29
2	14	9.2	16.03	1.0682	13.97	.55	.....	.....	84.00
2	15	8.9	16.00	1.0656	14.04	.00	.1313	.94	87.68
3	16	9.0	16.29	1.0699	13.00	.58	.1250	.96	70.80
3	17	9.0	16.23	1.0665	13.76	.00	.1375	1.00	84.78
3	18	9.0	16.17	1.0665	13.01	.77	.1500	1.15	80.45
4	19	8.6	15.59	1.0630	12.75	.49	.1813	1.42	81.78
4	20	8.8	15.78	1.0647	13.12	.00	.....	.....	83.14
5	21	8.9	16.05	1.0656	13.33	.51	.2063	1.65	83.05
5	22	8.9	16.16	1.0660	13.00	.....	.....	.....	86.01
6	23	8.6	15.46	1.0634	12.89	.....	.....	.....	83.39
7	24	8.2	14.76	1.0604	11.67	.....	.2813	2.41	79.06
8	25	8.5	15.36	1.0630	12.88	.58	.....	.....	83.83
8	26	8.8	15.89	1.0652	13.63	.....	.....	.....	85.77
9	27	9.5	17.07	1.0704	14.97	.72	.....	.....	87.60
10	28	8.6	15.47	1.0634	13.19	.48	.1313	.99	85.26
10	29	8.9	16.11	1.0660	13.84	.45	.2083	1.49	85.90
11	30	8.9	16.09	1.0660	13.45	.46	.2000	1.49	83.59
11	31	9.0	16.17	1.0665	13.70	.46	.2000	1.46	84.72
12	32	8.5	15.89	1.0630	12.32	.91	.1500	1.22	80.05
12	33	8.6	15.47	1.0634	13.56	.64	.1063	.79	87.65
13	34	8.5	15.40	1.0630	12.91	.72	.1625	1.26	83.83
13	35	8.6	15.57	1.0639	12.97	.51	.3000	2.31	83.80
14	36	8.5	15.27	1.0626	13.04	.51	.2500	1.92	85.39
14	37	8.8	15.87	1.0652	12.92	.72	.....	.....	81.41
15	38	9.1	16.43	1.0674	13.74	.55	.1938	1.41	83.62
15	39	9.0	16.18	1.0665	13.85	.58	.1313	.95	85.59
16	40	9.2	16.62	1.0682	14.87	.55	.1563	1.05	89.47
16	41	9.1	16.46	1.0678	14.81	.47	.1250	.81	80.97
17	42	9.0	16.19	1.0665	13.76	.60	.1625	1.18	84.99
17	43	9.2	16.60	1.0687	14.34	.52	.1313	.91	85.01
18	44	9.0	16.29	1.0669	13.60	.55	.1625	1.19	83.42
18	45	8.4	15.10	1.0621	12.50	.....	.....	.....	82.29
19	46	8.5	15.89	1.0630	12.73	.....	.....	.....	82.06

Résumé showing the mean composition of the raw juice for the campaign of 1886.

[November 24 to December 20.]

	Means.	Maxima.	Minima.
Specific gravity.....	1.0665	1.0739	1.0604
Degree Baumé.....	9.00	9.90	8.20
Degree Brix (per cent. total solids).....	16.20	17.88	14.78
Sucrose.....per cent.....	13.50	15.04	11.67
Reducing sugars(glucose, &c.)...do.....	.61	.91	.61
Albuminoids.....do.....	.1669	.3000	.0625
Albuminoids, per cent. sucrose.....	1.24	2.41	.45
Coefficient of purity.....	83.33	89.47	77.17
Total number of analyses, 46.			

COMPARISON OF RAW AND CLARIFIED JUICES.

In the following table analyses of the raw juices are only given for those days when the clarified juices were also examined:

TABLE II.—*Comparison of raw and clarified juices.*

[When two analyses are given the same date the first was sampled in the morning and the second in the afternoon.]

Date.	Number.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugar.	Albuminoids per cent. sucrose.	Coefficient of purity.
				<i>Per cent.</i>	<i>Per cent.</i>		
Nov. 25	3	9.2	16.66	13.90	.82		83.43
26	4	8.6	15.55	12.28	.87	1.32	78.97
26	5	9.1	16.37	13.60	.74	.64	83.08
27	6	8.6	15.55	12.00	.73	1.88	77.17
28	7	9.5	17.21	14.36	.46	1.04	83.43
28	8	9.5	17.07	14.21	.40	1.14	83.24
29	9	9.9	17.88	15.04	.43	.91	84.11
29	10	9.6	17.33	14.54	.53		83.90
30	11	9.4	16.90	13.91	.46	.85	82.30
30	12	9.2	16.69	14.21	.39		85.14
Dec. 1	13	9.5	17.14	13.95	.68	.90	81.89
1	14	9.2	16.63	13.97	.55		84.00
2	15	8.9	16.00	14.04	.67	.95	87.75
2	16	9.0	16.29	13.00	.58	.96	79.80
3	17	9.0	16.23	13.76	.60	1.00	84.78
3	18	9.0	16.17	13.01	.77	1.15	80.45
4	19	8.6	15.59	12.75	.49	1.42	81.78
4	20	8.8	15.78	13.12	.60		83.14
9	27	9.5	17.07	14.97	.72		87.69
10	28	8.6	15.47	13.19	.48		85.26
10	29	8.9	16.11	13.84	.45	1.49	85.90
11	30	8.9	16.09	13.45	.46	1.49	83.59
12	32	8.5	15.39	12.82	.91	1.22	80.05
12	33	8.6	15.47	13.56	.64		87.67
13	34	8.5	15.40	12.91	.72	1.26	83.81
13	35	8.6	15.57	12.97	.51	2.31	83.30
14	36	8.5	15.27	13.04	.51	1.92	85.39
14	37	8.8	15.87	12.92	.72		81.41
15	38	9.1	16.43	13.74	.55		83.62
15	39	9.0	16.18	13.85	.58	1.26	85.59
17	42	9.0	16.19	13.76	.60	1.18	84.99
17	43	9.2	16.69	14.84	.52	.91	85.91
18	44	9.0	16.20	13.60	.55	1.10	83.48
Means.....			16.26	13.58	.60	1.24	83.52

TABLE II.—*Comparison of raw and clarified juices*—Continued.

Date.	Number.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugar.	Albuminoids per cent. sucrose.	Coefficient of purity.
				<i>Per cent.</i>	<i>Per cent.</i>		
Nov. 25	3	10.2	18.37	14.92	.85	-----	81.22
26	4	9.9	17.87	14.82	.79	.51	82.93
26	5	9.6	17.31	14.88	.79	.52	82.93
27	6	9.1	16.87	12.95	.82	1.01	79.11
28	7	9.3	17.79	11.98	.61	.71	84.20
28	8	10.0	18.04	15.17	.50	.74	84.09
29	9	10.5	18.98	10.01	.68	.47	84.35
29	10	10.1	18.19	15.71	.53	-----	86.37
30	11	10.3	18.70	16.04	.61	.55	85.78
30	12	9.7	17.47	14.63	.46	-----	83.74
Dec. 1	13	9.7	17.46	14.11	.84	.71	80.81
1	14	9.7	17.39	14.59	.42	-----	82.94
2	15	9.9	17.87	14.27	.46	.88	79.85
3	16	9.4	16.80	14.85	.55	.58	87.92
3	17	9.6	17.27	14.56	.43	.69	84.31
3	18	9.7	17.47	14.86	.71	.59	85.06
4	19	9.9	17.79	14.64	.49	.56	82.29
4	20	9.4	16.80	14.18	.46	-----	83.96
9	27	9.1	16.40	14.20	.60	-----	86.59
10	28	9.5	17.07	14.57	.62	-----	85.35
10	29	9.5	17.19	15.07	.49	.87	87.67
11	30	9.6	17.89	15.15	.50	.83	87.11
12	32	9.5	17.09	14.56	.70	.86	85.20
12	33	8.8	15.87	13.48	.62	-----	84.94
13	34	9.0	16.31	14.07	.65	.98	86.14
13	35	9.0	17.39	15.09	.63	.79	86.77
14	36	9.7	17.47	14.94	.50	1.09	85.52
14	37	9.4	16.94	14.31	.48	-----	84.47
15	38	9.6	17.33	14.91	.62	-----	86.04
15	39	10.5	18.93	16.35	.43	.95	86.37
17	42	10.1	18.17	15.91	.45	.63	87.56
17	43	9.7	17.47	15.23	.55	.57	87.18
18	44	9.4	17.00	14.90	.64	.59	87.65
Means	-----	-----	17.46	14.80	.59	.72	84.76

The increase in the coefficient of purity, as shown by Table II, was 1.24. There was but little change in the relative proportions of sucrose and reducing sugars. In the raw juice the average quantity of reducing sugars per cent. sucrose was 4.41; after clarification this proportion was reduced to 3.98. This slight reduction was probably due to the formation of a glucosate of lime, which was subsequently decomposed, leaving the products of the decomposition in solution.

In order to render the percentages of albuminoids more readily comparable they have been expressed in terms of the sucrose. To obtain the actual per cent. albuminoids based on the weight of the juice, multiply the per cent. sucrose by the number given in the column albuminoids per cent. sucrose.

In the raw juice the albuminoids per cent. sucrose was 1.24, and in the clarified juice .72, showing that some of the total albuminoids were still retained by the juice.

In 1884 the processes of defecation and clarification removed 45.71 per cent. of the total albuminoids; in 1885-'86, 45.01; in 1886, 41.93.

COMPARISON OF RAW, CLARIFIED, AND FILTERED JUICES AND FILTERED SIRUP.

Analyses were conducted for a period of sixteen days to determine the effect of filtration through animal charcoal on the juice. These analyses are given in Table III.

TABLE III.—Comparison of raw juices, clarified juices, filtered juices, and filtered sirup for a period of sixteen days.

RAW JUICES.

Date.	Number.	Degree Baumé.	Degree Brx.	Sucrose.	Reducing sugars.	Coefficient of purity.
				<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 25.....	3	9.2	16.66	13.90	.82	83.43
26.....	4	8.6	15.55	12.28	.87	78.97
26.....	5	9.1	16.37	13.60	.74	83.06
27.....	6	8.6	15.55	12.00	.73	77.17
28.....	7	9.5	17.21	14.36	.46	83.43
28.....	8	9.5	17.07	14.21	.49	83.24
29.....	9	9.9	17.88	15.04	.43	84.11
29.....	10	9.6	17.33	14.54	.53	83.90
30.....	11	9.4	16.90	13.91	.46	82.80
30.....	12	9.2	16.69	14.21	.39	85.14
Dec. 1.....	13	9.5	17.14	13.95	.68	81.39
2.....	15	8.9	16.00	14.04	.60	87.75
2.....	16	9.0	16.29	13.00	.58	79.80
3.....	17	9.0	16.23	13.76	.69	84.78
4.....	19	8.6	15.59	12.75	.49	81.78
4.....	20	8.8	15.78	13.12	.60	83.14
Means		9.1	16.52	13.67	.60	82.75

CLARIFIED JUICES.

Nov. 25.....	3	10.2	18.37	14.92	.85	81.22
26.....	4	9.9	17.87	14.82	.79	82.98
26.....	5	9.6	17.34	14.38	.79	82.98
27.....	6	9.1	16.37	12.95	.82	79.11
28.....	7	9.3	17.79	14.98	.61	84.20
28.....	8	10.0	18.04	15.17	.50	84.09
29.....	9	10.5	18.98	16.01	.68	84.35
29.....	10	10.1	18.19	15.71	.63	86.37
30.....	11	10.3	18.70	16.04	.61	85.78
30.....	12	9.7	17.47	14.63	.46	83.74
Dec. 1.....	13	9.7	17.46	14.11	.84	80.81
2.....	15	9.9	17.87	14.27	.46	79.65
2.....	16	9.4	16.69	14.85	.55	89.92
3.....	17	9.6	17.27	14.56	.43	84.31
4.....	19	9.9	17.79	14.64	.49	82.29
4.....	20	9.4	16.89	14.18	.46	82.96
Means		9.7	17.64	14.76	.62	83.62

FILTERED JUICES.

Nov. 25.....	3	9.0	16.17	12.48	.61	77.18
26.....	4	9.8	17.67	14.44	.77	82.86
26.....	5	9.2	16.61	13.71	.77	82.54
27.....	6	9.5	17.10	14.28	.89	83.61
28.....	7	9.6	17.33	13.60	.87	78.48
28.....	8	10.6	19.14	16.19	.60	84.69
29.....	9	10.2	18.58	15.34	.48	82.56
29.....	10	10.7	19.29	16.24	.55	84.19
30.....	11	12.3	22.22	18.52	.67	83.35
30.....	12	10.2	18.37	15.27	.44	83.12
Dec. 1.....	13	10.7	19.39	15.63	.66	80.61
2.....	15	9.7	17.47	14.20	.51	80.28
2.....	16	9.4	16.89	14.45	.62	84.96
3.....	17	10.6	19.07	14.95	.70	78.40
4.....	19	9.5	17.19	14.56	.58	84.70
4.....	20	9.1	16.49	14.08	.44	85.26
Means		10.0	18.06	14.87	.64	82.14

TABLE III.—*Comparison of raw juices, clarified juices, &c.*—Continued

FILTERED SIRUPS.

Date.	Number.	Degree Baumé.	Degree Brix.	Sucrose.	Reducing sugars.	Coefficient of purity.
				<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 25.....	3	24.3	44.55	36.10	1.88	81.07
26.....	4	23.4	42.79	35.98	2.29	83.97
26.....	5	21.7	39.56	33.22	2.35	83.97
27.....	6	22.3	40.70	33.56	2.61	82.46
28.....	7	23.3	42.59	34.84	3.00	81.80
28.....	8	22.6	41.36	33.01	2.19	79.81
29.....	9	19.8	38.09	33.00	1.67	77.58
29.....	10	23.6	43.15	36.10	1.96	83.66
30.....	11	23.4	42.92	35.75	1.90	83.29
30.....	12	23.7	43.40	36.54	1.88	83.96
Dec. 1.....	13	23.6	43.22	35.49	1.67	82.11
2.....	15	21.4	39.10	32.58	1.98	83.32
2.....	16	24.5	45.38	37.23	1.65	82.04
3.....	17	24.1	44.10	36.24	1.70	84.44
4.....	19	24.3	44.00	36.91	1.48	82.76
4.....	20	20.8	38.00	31.80	1.64	83.68
Means		23.0	41.17	34.58	2.00	82.30

The results of these analyses are not surprising, when we consider the quality of the bone-black used. Mr. O. B. Stillman, a Boston refiner, examined this char and pronounced it to be in a very bad condition. It weighed nearly seventy pounds to the cubic foot. This is nearly twenty pounds heavier than good char should weigh.

The decolorizing properties of this bone-black were good, but as it was already laden with impurities it did not improve the purity of the juice, but, on the contrary, reduced it. This was due to the impurities in the char being redissolved. The sirups being heavier, and already nearly saturated with soluble matter, yield their impurities more readily to the action of the bone-black and are improved in purity. ¹Reference to the first report of this station, giving analyses of raw and filtered juices, will show this same result. The char in use at that time was even worse than last season.

I do not believe that the benefit from the mechanical filtration and the decolorization will balance the damage to the juice resulting from the use of spent bone-black.

THE FILTER-PRESSES.

The use of the filter-presses was continued this season with even greater success than in 1885-'86.

¹ Chem. Bulletin No. 5, pp. 49-50.

Very few analyses of the press-cakes were made, except to determine their value for fertilizing purposes. However, the few analyses that were made are presented in the following table:

TABLE IV.—*Analyses of press-cake.*

Date.	Sucrose.
1886.	<i>Per cent.</i>
November 30.....	7.40
December 1.....	7.24
3.....	7.34
4.....	8.06
Means.....	7.51

No record was kept in the sugar-house of the quantity of juice recovered by the presses. In fact it would be quite difficult to determine just the proportion of the juice flowing from the presses that would be lost in ordinary work.

This season we found it necessary to empty one press once for every 2,889 gallons of juice expressed by the mills. The total amount of juice was 1,271,205 gallons, hence the number of presses of press-cake was $1,271,205 \div 2,889 = 440$. The average weight of the press-cake per press was 330 pounds: $330 \times 440 = 145,200$ pounds of press-cake for the entire season. The amount of press-cake per ton of cane was 20.15 pounds.

In the work with the¹ experimental press in 1884 on thoroughly drained "blanket" scums the yield of juice was 80 per cent. The average skimmings and settlings, after long standing and decantation of the clear juice, are much thinner than the blanket, and would yield from 85 to 90 per cent. juice by filter-pressing. In order to under rather than over estimate the work of the presses, I will base my estimates on the actual yield obtained with the small experimental press. It may be well to state here that the work on a small scale was no better than with the large presses.

On the above basis the press-cake forms 20 per cent. of the total weight of skimmings filtered, hence $145,200 \div 20 \times 100 = 726,000$, the total number of pounds of skimmings. These figures show that even on a low estimate $6\frac{1}{2}$ per cent. of the juice is lost in the skimmings.

As the presses save at least 80 per cent. of this loss, the saving of juice at Magnolia this season was 580,000 pounds.

As I have repeatedly stated, I consider this estimate a very low one. I have no doubt but that carefully conducted experiments would show a saving of 820,000 pounds of juice. With the filter-press arrangement at Magnolia it is impossible to keep a separate account of the juice recovered.

¹ Chem. Bulletin No. 5, p. 59.

COMMERCIAL VALUE OF THE PRESS-CAKE.

The samples of press-cake sent to Washington for analysis reached there in such a damaged condition that it was useless to analyze them, hence the value of the cake is based on last season's determinations.¹

Total weight of press-cake 145,200 pounds, or 72.6 tons of 2,000 pounds each. The total value at \$10.64 per ton is \$772.46.

PRESSURE-REGULATOR FOR FILTER-PRESSES.

In order to do good work with the presses it is essential to maintain a regular pressure, free from sudden changes or shocks. This can be accomplished by several methods, but the simplest and one as reliable as any other is the following, devised some years since by Mr. O. B. Stillman:

This apparatus consists of a pump (Blake or other suitable pattern), an air-tight receiver similar to an ordinary *montejus* in shape, and a damper-regulator.

In the bottom of the receiver there is a central depression. The discharge-pipe from the pump connects directly with the receiver; the feed-pipe to the presses passes through the top of the receiver and dips to the central depression; connection with the damper-regulator is made by means of a small tube leading from the top of the receiver. The lever of the regulator is connected with the steam-inlet to the pump. The operation of the apparatus is as follows:

The pump is started and forces the liquor into the receiver, whence it passes through the feed-pipe to the presses. When the pressure exceeds that required the lever on the regulator raises and partly or entirely closes the steam-inlet to the pump, and as soon as the pressure falls below the limit the steam-valve is automatically opened.

The use of this apparatus relieves the press-man from the necessity of regulating the pump. The pressure increases or decreases gradually, hence the presses work to the best advantage. This device is employed at the Soledad Estate, near Cienfuegos, Cuba, and gives perfect satisfaction.

ANALYSES OF SUGARS.

TABLE V.—*First sugars.*

Date.	Lot.	Sucrose.	Date.	Lot.	Sucrose.
1886.		<i>Per cent.</i>	1886.		<i>Per cent.</i>
Nov. 22	13	90.0	Dec. 6	27	99.1
24	14	90.3	9	28	98.7
24	15	98.8	9	29	98.0
25	16	90.1	10	30	98.2
26	17	99.3	12	31	98.8
28	18	90.5	13	32	90.0
28	19	98.5	15	33	99.2
29	20	97.8	17	34	98.7
30	21	98.9	17	35	99.2
Dec. 1	22	98.9	19	36	98.9
2	23	98.8	20	37	98.8
3	24	97.8	21	38	98.9
4	25	97.8			
6	26	99.2	Mean	.....	98.78

¹ Chem. Bulletin No. 11, p. 16.

TABLE VI.—*Second sugars.*

Date.	Lot.	Sucrose.	Date.	Lot.	Sucrose.
1886.		<i>Per cent.</i>	1886.		<i>Per cent.</i>
Nov. 22	1	90.6	Dec. 10	9	91.3
26	2	91.4	15	10	91.5
29	3	92.6	19	11	91.6
Dec. 1	4	85.2	22	12	92.8
3	5	88.1	23	13	90.8
5	6	90.5			
7	7	89.2	Mean.	.....	90.3
9	8	89.1			

The first sugars graded "off white," the seconds were boiled to string proof. But two sugars were made.

ANALYSES OF MOLASSES.

TABLE VII.—*Analyses of molasses from first sugars. (II Molasses.)*

Date.	Lot.	Degree Baumé.	Degree Brix.	Sucrose	Reducing sugars.	Sucrose at 50° Brix or 27° Baumé.	Reducing sugars at 50° Brix or 27° Baumé.	Coefficient of purity.
				<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	
Nov. 25	16	30.9	57.08	35.00	5.88	30.66	5.15	61.22
26	17	29.9	55.20	35.70	6.25	32.34	5.66	64.68
28	19	28.8	53.24	33.00	6.45	31.02	6.06	62.04
29	20	29.2	53.84	34.00	5.00	31.57	4.64	63.15
30	21	28.9	53.30	34.20	4.00	32.08	3.75	64.16
Dec. 1	22	30.3	56.00	36.70	5.40	32.85	4.83	65.54
2	23	26.8	49.20	32.00	5.00	32.51	5.08	65.02
3	24	29.6	54.70	35.00	6.37	31.90	5.82	63.98
9	28	29.7	54.90	36.20	5.40	32.96	4.92	65.92
12	31	29.1	53.70	38.80	4.63	36.12	4.31	72.24
13	32	29.6	54.70	37.00	5.62	33.82	5.14	67.63
15	33	29.1	53.70	37.10	4.83	34.54	4.49	69.08
17	34	30.1	55.50	39.80	4.83	35.86	4.35	71.72
17	35	30.1	55.50	38.50	4.44	34.69	4.00	69.38
19	36	29.5	54.50	38.40	3.97	35.23	3.64	70.46
20	37	28.7	52.80	38.70	5.71	31.91	5.40	63.83
Means	.....	29.4	54.24	35.94	5.24	33.13	4.83	66.26

TABLE VIII.—*Analyses of molasses from second sugars. (III Molasses.)*

Date.	Lot.	Degree Baumé.	Degree Brix.	Sucrose, single polarization.	Sucrose, double polarization.	Reducing sugars.	Sucrose, single polarization at 76° Brix or 40° Baumé.	Sucrose, double polarization at 76° Brix or 40° Baumé.	Reducing sugars at 76° Brix or 40° Baumé.	Coefficient of purity (based on single polarization).
				<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	
Nov. 26	1	40.8	76.92	32.80	39.90	19.75	32.41	39.42	19.51	42.64
26	2	40.3	75.92	32.30	40.07	19.60	32.46	40.20	19.67	42.71
Dec. 2	3	41.5	78.51	33.40	41.21	13.90	32.23	39.78	12.41	42.41
2	4	40.5	76.41	32.80	40.39	13.15	32.06	40.21	13.09	42.97
3	5	40.5	76.43	32.90	40.62	13.90	32.75	40.44	13.84	42.99
7	7	34.8	64.85	28.80	.....	11.42	33.71	.....	13.36	44.35
9	8	40.1	75.48	31.20	39.48	13.80	31.30	39.24	13.94	41.18
10	9	42.2	79.91	32.60	40.61	15.74	31.62	39.40	15.31	41.61
15	10	41.9	79.31	33.70	40.68	14.01	32.27	38.95	13.44	42.46
19	11	41.7	78.86	35.00	42.20	13.80	33.78	40.72	13.31	44.46
Means	.....	40.5	76.26	32.54	41.13	14.91	33.52	39.62	14.80	42.79

It will be noticed in the above tables that the analyses have been reduced to the basis of a molasses of a stated density. This facilitates the comparison of the results, the percentages being directly comparable with one another.

The arbitrary density 50° Brix (Baumé 27°·2) has been taken for molasses from firsts and 76° Brix (Baumé 40°·3) for molasses from seconds.

Fifty and seventy-six degrees Brix were selected as standards of comparison, since they represent approximately the average densities of molasses from first and second sugars.

LOSS OF SUGAR IN THE PROCESSES OF MANUFACTURE.

Unless careful arrangements for measurements are provided it is almost impossible to trace losses in manufacture. At Magnolia there is no provision for measuring either sirups or *masses cuites*. The quantities of cane juice, sugars, and molasses are accurately known, and they, together with the analytical work, are the basis for the following calculations :

Loss of sugar in the processes of manufacture.

[Data for calculations.]

First sugar (98°·78 polarization), per ton of cane.....	pounds..	120. 47
Second sugar (90°·30 polarization, .50 per cent. glucose) per ton of cane..do....	do....	40. 53
Molasses (41°·13 double polarization, 14·91 per cent. glucose, 76°·26 Brix), per ton of cane	pounds..	58. 17
Press cake (7°·51 polarization .30 per cent. glucose), per ton of cane...do....	do....	20. 15
Sucrose in juice	per cent..	13. 50
Glucose in juice	do....	. 61
Juice per ton of cane	pounds..	1,560. 00
Sucrose per ton of cane :		
In first sugars	pounds..	119. 00
In second sugars	do....	36. 60
In press cakes	do....	1. 51
In molasses	do....	23. 93
Total sucrose accounted for as above	do....	181. 04
Total sucrose in juice extracted	do....	210. 60
Sucrose to be accounted for	do....	29. 56
Sucrose in juice extracted		210. 60
Sucrose in sugars and press cake		157. 11
Sucrose that would pass into the molasses were there no losses in manufacture		53. 49
Glucose per ton of cane :		
In the juice extracted	pounds..	9. 52
In the second sugars, .20 pounds; press cake, .06 pounds	do....	. 26
Glucose that would pass into the molasses were there no losses in manufacture		9. 36

Assuming that had there been no inversion and no losses in evaporation, &c., the molasses would have contained the same proportion of non-sugars as the actual molasses did, we obtain the following:

	Theoretical composition of molasses.	Actual composition of molasses.
Sucrose..... per cent..	47.77	41.13
Glucose.....do.....	8.27	14.91
Degree Brix.....	76.26	76.26
Glucose, per cent. sucrose...	17.31	36.25
Coefficient of purity.....	62.64	53.93
Pounds molasses.....	111.97	58.17

The actual loss from inversion is the difference between the sucrose in the theoretical molasses and the actual: $47.77 - 41.13 = 6.64$ per cent. sucrose inverted, based on the weight of the molasses; $58.17 \times .0664 = 3.86$ pounds of sucrose per ton of cane.

The difficulty is to exactly locate this inversion. The analyses of juices and sirups show very little inversion between the juice box and the vacuum-pau, but the actual extent of this inversion could not be determined.

The beet-sugar manufacturers charge about .60¹ per cent. the weight of the beets of sucrose to loss in the evaporation and bone-charcoal filters. This is based on an average sugar content in beet about the same as that in our cane. This corresponds to a loss of 12 pounds of sucrose.

RÉSUMÉ.

Sucrose extracted in the juice per ton of cane.....	pounds..	210.60
Sucrose in sugars, molasses, and press-cake per ton of cane.....	do....	181.04
Sucrose inverted.....	do....	3.86
Sucrose lost in evaporation and bone-black.....	do....	12.00
Total sucrose accounted for.....	do....	196.90
Total percentage of the sucrose accounted for.....		93.49
Total percentage of the sucrose unaccounted for.....		6.51
		100.00

Accounting for the sucrose on a basis of the weight of the juice we have:

Sucrose, per cent. juice.

First sugars.....	pounds..	7.628
Second sugars.....	do....	2.346
Molasses.....	do....	1.533
Press-cake.....	do....	.097
Inverted.....	do....	.248
Lost in evaporation, &c.....	do....	.768
Unaccounted for.....	do....	.880
		13.500

¹ Fabrication du Sucre. Horsin-Deon, p. 133.

It will be seen from the above table that there is a large proportion of sugar unaccounted for, even after a liberal deduction for losses in evaporation, filtration, &c. This loss of sugar should be located, if possible. Unfortunately the available data are insufficient to do so this season, and this important problem must be left to another crop.

SUMMARY OF DATA COLLECTED AT MAGNOLIA STATION, SEASON OF 1886-'87.

Governor Warmoth kindly allowed me free access to the records of the sugar-houses, from which the following data were obtained:

TABLE IX.—*Tons of cane worked, weight of juice extracted, per cent. of extraction, weight of first and second sugars and molasses per ton of cane for each of the four periods¹ into which the season was divided.*

Period.	Cane worked.	Juice extracted.	Extraction.	Weight of sugar per ton.		Molasses per ton.
				First sugar.	Second sugar.	
	<i>Tons.</i>	<i>Pounds.</i>	<i>Per cent.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
First period	2, 113. 76	3, 225, 385	78. 29	116. 40	36. 27	54. 05
Second period	2, 410. 72	3, 848, 740	79. 82	124. 6	40. 35	63. 12
Third period	920. 47	1, 430, 881	77. 73	111. 57	34. 16	48. 53
Fourth period	1, 758. 33	2, 757, 870	78. 42	124. 49	44. 59	61. 06
Total	7, 203. 30	11, 262, 870	Means: 78. 17	120. 47	40. 53	58. 17

¹ The divisions of the season into periods were arbitrary, and were made when bad weather or other cause of delay permitted a thorough cleaning of the house.

Per cent. of yield, sugars	8. 05
Per cent. of yield, first sugar	6. 02
Per cent. of yield, second sugar	2. 03
Pounds first sugar (polarization 98°. 78) per ton of cane	120. 47
Pounds second sugar (polarization 90°. 03) per ton of cane	40. 53
Total sugar per ton of cane	161. 00
Per cent. of total sugar obtained in first product	74. 82
Per cent. of total sugar obtained in second product	25. 18
Total number of acres of cane rolled	590. 81
Total tons of cane rolled	7, 203. 3
Tons of cane per acre	12. 19
Total pounds of sugar made	1, 159, 708
Pounds of sugar per acre	1, 962. 6
Total pounds molasses made (11.6 pounds per gallon)	418, 563
Pounds molasses per acre	708. 45
Pounds molasses per ton of cane	58. 1 ¹

TABLE X.—*Comparison of yield of sugar and molasses, seasons of 1884-'85, 1885-'86, and 1886-'87.*

	1886-'87.	1885-'86.	1884-'85.
Yield of first and second sugars	8. 05	7. 43	6. 87
Yield of all sugars			7. 92
Yield of first and second sugars per ton of cane .. pounds ..	161. 00	148. 75	137. 89
Yield of molasses per ton of cane	58. 17		58. 25

¹ In 1884-'85 three sugars were made.

EXPERIMENTS IN FILTRATION.

When in New Orleans in November I received an invitation to visit the experiment station and witness a test of the Kleemann process for the filtration of the juice. This test on a small scale was very successful, and demonstrated clearly that all the juice could easily be filtered through presses.

This process was invented by Fritz Kleemann, of Schoeniugen, Brunswick, Germany. It has been patented in all sugar-producing countries.

The first tests on a large scale with cane were made in Demerara at the following estates: Nonpareil, Lusignan, Enmore, and others. The Nonpareil sugar-houses filtered the juice from 400 long tons of cane per day, through eight presses of eighteen chambers each. These tests were made in May, 1886, since when the process has been introduced into Porto Rico and Cuba.

The following description of the process was given me by Mr. Ernst Schulze, representing the owners of the process:

The raw juice is treated in the defecators or clarifiers with lime, as usual, except that smaller quantity is required. The juice is then heated to a temperature between 160° and 180° Fahr., and finely ground lignite or brown coal is added. The lignite must be reduced to as fine a state of division as is practicable. The quantity of lignite to be added varies with the amount of sugar contained in the juice, and ranges from 5 to 10 per cent. of the weight of the sugar. The temperature of the mixture is maintained at from 150° to 170° Fahr. fifteen or twenty minutes, and is then pumped to the filter-presses. The filtered juice passes directly to the evaporating pans, and the sirup without further clarification or settling can be immediately boiled in the vacuum-pan.

The juice left in the press-cake in the presses is obtained by displacement with cold water.

One thirty-chamber Kroog press will filter 20,000 gallons of juice treated by the Kleemann process in twenty-four hours, ample time being allowed for displacement of the juice left in the press-cake and for cleaning the presses, changing cloths, &c. An ordinary laborer can manipulate the presses.

The amount of precipitate retained by a thirty-chamber press will average 770 pounds. This precipitate contains 50 per cent. of its weight of juice, nearly all of which can be obtained by displacement.

The amount of press-cake per ton of cane is approximately 46 pounds, half of which is juice containing an average of about 13 per cent. sucrose. Were this juice thrown away with the press-cake it would entail a loss of $46 \times .50 \times .13 = 3$ pounds sucrose per ton of cane worked.

Even at a low valuation per pound for sucrose, this loss, amounting to nearly 30,000 pounds of sugar for an average crop at Magnolia, is a

very large item. These figures are based on an extraction of 78 per cent. of juice from the cane.

The Kroog presses are provided with a graduated juice-box for measuring the amount of displaced juice. Practice has demonstrated that the theoretical amount of water required to displace the juice from the cakes is not sufficient, consequently a little more is always used. The quantity for a twenty-four-chamber press is 160 litres, and for a thirty-chamber press 200 litres of water.

Mr. Heine, of St. Burghard, near Halberstadt, Germany, made a number of experiments to determine the effect of using too much water. He analyzed the juice at different stages of the displacement process. The press used was a twenty-four chamber, Kroog system.

The normal juice from the presses had a coefficient of purity of 83.38.

The results of these experiments are given in the following table. Under the column marked "litres" the quantity of displacement water is indicated :

Litres.	Degree Brix.	Sucroso.	Coefficient of purity	Lime salts in 100 parts of dry matter in the juice, not precipitated by carbonic acid. Weighed as CaO.
		<i>Per cent.</i>		
40	9.23	7.78	84.29	0.0010
80	8.40	7.13	84.87	0.0095
120	7.83	6.41	81.89	0.0820
160	7.00	5.70	81.43	1.1265
200	5.50	4.15	75.04	1.6464
240	3.10	2.15	60.36	2.9750
280	1.83	1.04	56.83	5.1745
320	0.93	0.43	46.23	8.7973
360	0.80	0.31	38.75	12.0902

The water employed in these experiments was cold. The reason for limiting the quantity of water to 160 litres per twenty-four-chamber press is evident from an inspection of the above table.

KLEEMANN PROCESS.

In reply to a letter of inquiry, Mr. Kleemann, the inventor of this process, has kindly given me a detailed plan for working. The following extracts from his letter will be of interest to the planters:

The charcoal you mention as having used I suppose was vegetable charcoal ground to a fine powder. * * * Certainly you have employed a substance that next to brown coal is the best aid to filtration, owing to its specific gravity and its absorbing powers of mucilaginous matters. Certain precautions, however, have to be adopted in its use, and its price compares unfavorably with that of brown coal. Even when close-woven filter-cloth is used in the press, fine particles of char have a tendency to pass through the cloth along with the juice for some time after filtration¹ has started, and this liquor has to be turned back to be filtered over again after a suffi-

¹This difficulty was not met with in the experiment at Magnolia. G. L. S.

ciently fine filtering surface of foculent matters and charcoal has been formed on the surface of the cloth.

Juice treated with brown coal, on the other hand, runs quite bright or nearly so from the first running of the press, decolorizes considerably, and the cakes formed in the press part easier with their sugar when it is desired to wash them out than cakes formed of vegetable char.

For your future guidance allow me to suggest what I consider the best mode of treating juice with brown coal to effect rapid and good filtration and at the same time use the minimum amount of brown coal in the operations. I make this suggestion on the supposition you are carrying out your experiments on an estate containing all the most modern appliances for successfully treating after it has been filtered, namely, double or triple effects vacuum-pans and centrifugals.

After the juice has been defecated in the usual manner allow it to subside for a few minutes, then brush off the skimmings into a tank and run the juice into another (preferably a circular one fitted with revolving stirrers), where the brown coal has to be added. As soon as the bottoms are reached they also have to be run into the skimmings tanks. The brown coal is now added to the tank containing the juice, and after being thoroughly mixed it is forced through the filter press, finishing off with a pressure of about 75 pounds per square inch. In some cases 50 to 60 pounds pressure will be found quite sufficient, and a speed in the filtration ought to be obtained of 9 gallons per square foot of filtering area per hour, or for a press containing 400 square feet of filtering area 3,600 gallons per hour of filtered liquor. After the thin juice has been brought to about 20° Baumé in the triple effect, certain albuminous compounds that were soluble in thin juice now¹ precipitate out at the higher density, and it is necessary to again add some ascertained proportion of brown coal to the liquor and pass through a press before being taken into the vacuum-pan.

By the action of the brown coal the liquor is considerably decolorized at this point, and as all gummy matters have been previously taken out of the juice the liquor will filter through rapidly by simple gravitation from a tank situated 6 to 10 feet above the press. The cakes taken from this press are used over again for the filtration of the defecated juice. The skimmings and bottoms are mixed either with fresh brown coal or with that taken from the gravitation-press and filtered in a press by themselves. By dividing the work in the manner I have suggested, more work can be got through in a given time, with better results and using a smaller proportion of brown coal, than if it had been added to the juice, skimmings, and bottoms together in the defecating tank.

Tests were made on a laboratory scale with lignite from Avery's Island. The results were very satisfactory. It is proposed to repeat these experiments on a large scale.

TEST OF THE KLEEMANN PROCESS AT MAGNOLIA.

Early in December, at the request of Mr. D. D. Colcock, of the Sugar Exchange, New Orleans, the Commissioner of Agriculture directed me to test this process on a practical working scale.

A sufficient quantity of lignite could not be procured, so, in accordance with the suggestion of Mr. Ernst Schulze, representing the owners of the process, finely ground charcoal was substituted. Experiment

¹ This was not the case in the experiment at Magnolia. The sirup remained perfectly clear without the slightest trace of precipitate. There was no necessity for a subsequent settling or filtration of the sirup. G. L. S.

on a small scale showed that a slight modification of the process must be made where charcoal, bituminous coal, or certain other substitutes for lignite are employed.

The clarifiers at Magnolia are of the ordinary form and have a capacity of 533 gallons. The filter-presses were manufactured by the Hallesche Maschinenfabrik, of Halle, Germany. An ordinary piston-pump was used to force the juice through the presses. The juice was limed as usual, *i. e.*, to neutrality. In order to determine the amount of charcoal required, experiments were made with varying quantities.

(1) Ten per cent. of the weight of the sugar in the juice.

(2) Seven and a half per cent.

(3) Five per cent.

Any difficulty in filtration would indicate too little charcoal. As a result of this experiment it was found that the juice filtered equally well with 5 per cent. as with 10. Five per cent. is probably as little as could be successfully employed.

The juice was rapidly heated to the boiling point, after liming, before the addition of the charcoal. The charcoal having been added the mixture was boiled and stirred thoroughly for ten or fifteen minutes and then forced through the presses.

One twenty-one-chamber press filtered 2,670 gallons of juice in three hours, at the end of which time it was opened and the press-cake removed. The chambers of these presses are not as large as those of the Kroog presses.

The filtered juice was perfectly clear and bright. It was immediately converted into sirup in the double effect. This sirup was as bright as the filtered juice. A portion of the sirup after standing several days in a glass vessel did not show the slightest sediment.

Analyses were made of the juice at frequent intervals during the work. A portion was taken from each sample for the determination of the albuminoids.

The proportion of albuminoids are expressed, in the table, both as a percentage of the weight of the juice and in terms of the sucrose.

The first sample of the juice was taken from the first clarifier; and the first sample of clarified juice from the first portion of the filtered juice, consequently these samples represent the same juice before and after clarification. The rest of the samples were taken at intervals from the presses and from every third clarifier of juice.

The average of these results will represent as nearly as possible the same juice before and after treatment.

TABLE XI.—*Showing analyses of juices before and after treatment by Kleemann process.*

Number.	A.					B.						
	Total solids (degree Brix.)		Albuminoids.	Albuminoids per cent. an-crose.	Coefficient of purity.	Total solids (degree Brix.)		Albuminoids.	Albuminoids per cent. an-crose.	Coefficient of purity.	Charcoal per cent. sucrose.	
	Pr. ct.	Pr. ct.				Pr. ct.	Pr. ct.					
1	16.01	14.89	2500	1.68	93.00	15.31	14.89	1563	1.05	97.25	10.0	
2	16.19	13.54	1625	1.20	83.64	14.29	12.27	1438	1.17	85.86	10.0	
3	16.06	13.53	2188	1.02	84.24	16.06	14.53	1313	.90	87.21	10.0	
4	16.57	14.13	1875	1.32	85.27	16.83	14.78	1369	.93	87.30	10.0	
5	15.96	13.41			84.02	16.16	13.60			84.16	7.5	
6	16.09	13.61	2188	1.60	84.50	16.76	14.60	1025	1.10	87.11	7.5	
7	15.47	13.04	2825	2.01	84.20	16.81	14.62	1625	1.10	86.97	7.5	
8	15.97	13.34	3062	2.20	83.53	17.56	14.90	1613	1.08	84.85	7.5	
9	14.51	11.81	2038	2.48	81.80	17.01	14.43	1338	1.27	81.83	7.5	
10	15.27	12.43	2563	2.06	81.40	17.47	14.75	1875	1.27	81.43	7.5	
11	15.21	12.82			84.28	17.44	14.65			84.00	7.5	
12	15.70	13.17	2375	1.80	83.86	17.30	14.76	1762	1.19	85.32	5.0	
Means	15.75	13.31	2204	1.81	84.46	16.47	14.40	1552	1.11	86.60	.....	

Average increase in coefficient of purity equals 2.14.

In the preceding table column A represents raw juices, column B juices treated by Kleemann process. Referring to the table we find the average increase in the coefficient of purity by the ordinary process to be 1.24. Table XI shows an increase of 2.14 by the Kleemann process. This large increase in the purity of the juice would give a decided increase in the yield of sugars.

THE ALBUMINOIDS.

The reduction in the percentage of albuminoids was not as large as by the ordinary process. By the Kleemann process an average of 35.17 per cent. of the albuminoids were removed; by the ordinary process the reduction was nearly 45 per cent. I do not know to what extent this difference in the albuminoids would affect the working of the sirup. The sugarmaker reported that the sirup made by the Kleemann process in this test worked as easily as by the ordinary.

THE PRESS-CAKE.

The following analysis of the press-cake shows its value as a fertilizer:

Per cent. moisture	46.08
Per cent. phosphoric acid (P_2O_5)	1.64
Per cent. nitrogen	.42
Pounds phosphoric acid per ton	32.8
Value of phosphoric acid, at 9 cents per pound	\$2.95
Pounds nitrogen per ton	8.4
Value of nitrogen, at 19 cents per pound	\$1.60
Total commercial value, per ton	\$4.55

This process yields twice as much press-cake as the ordinary.

ADVANTAGES OF THE KLEEMANN PROCESS.

The increased coefficient of purity is not the only advantage of this process. There is an increase in the yield of sugar due to rapidity of working both juice and sirup. The quantity of sugar lost in the scums is reduced to a minimum, and the expense for labor is less.

In addition the press-cake is in an excellent mechanical condition for use as a fertilizer.

This process certainly merits a more thorough test both by the Department and the planters. Lignite of good quality, I am informed, is abundant near the sugar area of Louisiana, and can be obtained at a small cost.

CUBAN SUGAR-HOUSES.

Although the average Cuban sugar-house does no better work than the average in Louisiana, there are many estates where the results obtained are as good, if not better, than those of this country.

The enormous size and the great strength of the milling machinery is very noticeable. The carts are backed up to the carriers upon which the cane is thrown without attempting to place each stalk lengthwise of the carrier, as is usual in Louisiana. The mills are fed very heavily. The average percentage of extraction of the juice is low. This is largely due to the woodiness of the cane. The proportion of marc or fiber is considerably higher than in Louisiana.

On leaving the mill the juice passes through a calorisor, which utilizes the waste heat from the double or tripple effect and condenses a large proportion of the vapors. This is a double economy. It reduces the quantity of water required for the house and effects a notable saving in consumption of fuel. Very few Cuban sugar-houses have a sufficient supply of water.

After leaving the calorisor the juice is conducted into double-bottom pans of 750 gallons capacity, termed defecators. Here it is limed and heated to the boiling point, then settled. The clear juice is drawn off and the scum and settlings are run into "blow-ups." The contents of the "blow-ups," after heating to the boiling point, are filter-pressed as at Magnolia. The clear juice, including that coming from the filter-presses, is immediately concentrated.

Many of the houses still employ high-pressure vacuum-pans. The best practice for obtaining a maximum yield of first sugar is to make a medium grain, boiling at as low a temperature as possible and discharge the *masse cuite* as stiff as the strike-valve of the pan will permit. The *masse cuite* is dropped into wagons and left several hours to become cold.

Through the courtesy of Mr. E. F. Atkins, of Soledad, I am enabled to present a table showing the work of his house last season. This house

employs double-milling. The treatment of the juice is essentially that described above. The Soledad estate is the property of Messrs. E. Atkins & Co., of Boston. It is located on the Caunao River, about 15 miles from Cienfuegos.

Monthly results of work on Soledad estate for year 1886.

	January.	February.	March.	April.	May.	Entire crop.
Juice from cane.....	66.79	66.73	66.94	65.77	65.25	66.30
Density of juice Banné.....	9.40	10.17	10.70	11.09	11.19	10.49
Polarization of juice.....	15.29	16.32	17.10	17.46	18.20	16.87
Coefficient of purity of juice.....	88.30	88.86	88.43	88.10	90.00	88.74
Total sugars in juice.....	10.21	10.89	11.44	11.48	11.87	11.18
Yield of first sugars from cane.....	7.89	8.50	9.02	8.88	8.98	8.66
Test of first sugars.....	96.61	96.70	96.40	96.00	96.31	96.52
Yield of second sugars from cane.....	1.40	1.53	1.82	1.75	2.08	1.74
Test of second sugars.....	88.00	84.60	86.80	86.80	86.87	87.01
Total sugars from cane.....	9.38	10.03	10.84	10.63	11.06	10.40
Test of first molasses.....	50.36	53.63	54.10	53.20	54.56	53.17
Test of second molasses.....	38.10	38.00	41.50	39.70	40.43	39.55
Yield of first sugars, calculated into pure sugar of 100 polarization.....	7.62	8.22	8.70	8.58	8.64	8.35
Yield of second sugars, calculated into pure sugar of 100 polarization.....	1.31	1.32	1.58	1.50	1.81	1.50
Total yield of sugars, calculated into pure sugar of 100 polarization.....	8.93	9.54	10.28	10.08	10.45	9.85

Above percentages are calculated upon 100 pounds of cane ground.

Mr. Atkins is conducting a series of experiments to determine what cane will give him a maximum output of sugar at the least cost. Such experiments if made in Louisiana would probably prove very valuable.

The following table gives the results of analyses of cane from experimental plots:

Analyses of canes from experimental plots.

Number.	Variety.	Date.	Per 100 lbs. cane.		Analysis of juice.						
			Juice ex-tracted.	Baga-se.	Solids.	Density. Banné.	Coefficient of purity.	Polarization.	Glucose.	Impurities.	Sugar extracted from 100 pounds cane.
1	Crystallina...	Mar. 26	72.78	27.22	20.9	11.6	91.8	19.2	.60	1.04	13.97
2	Red Ribbon...	Mar. 26	73.17	26.83	20.2	11.2	91.5	18.5	.14	1.56	13.54
3	do.....	Apr. 9	73.17	26.83	21.7	12.0	93.0	20.2	.10	1.40	14.78
4	Crystallina...	Apr. 9	71.58	28.42	22.0	12.2	91.3	17.9	1.80	2.30	12.81
5	do.....	Apr. 17	73.07	26.93	21.7	12.0	89.8	10.5	.13	2.07	14.25
6	Red Ribbon...	Apr. 17	70.29	29.71	20.4	11.3	90.1	18.4	.15	1.85	12.93
7	Crystallina...	Apr. 19	74.52	25.48	22.6	12.5	90.7	20.5	.20	1.90	15.27
8	Red Ribbon...	Apr. 19	76.23	23.77	22.3	12.3	91.7	20.5	.15	1.65	15.63
9	Crystallina...	Apr. 20	71.48	28.52	22.4	12.4	90.1	20.2	.28	1.92	14.43
10	Red Ribbon...	Apr. 20	71.85	28.15	21.9	12.1	91.3	20.0	.31	1.69	14.37
11	Black Java...	Apr. 21	71.68	28.32	22.0	12.2	90.8	21.3	trace	.70	15.26
12	do.....	Apr. 24	71.64	28.36	21.4	11.8	96.3	20.6	.08	.71	14.75

¹ Sucrose in juice from 100 pounds cane.

NOTE.—Samples 1 and 2 from fields four years planted; samples 3, 4, 5, 6, 7, 8, 9, and 10, spring cane, ten months planted; samples 11 and 12, known as caña obscura field, eight years planted. The samples 1 to 10 were from river lands, 11 to 12 from side hill.

The results of these and other experiments indicate that the Black Java is the largest sugar producer for this locality.

These experiments are under the charge of the chemist of the house, Mr. F. A. Terry, of 19 Exchange Place, Boston.

CAROLINA ESTATE.

The work of the Carolina estate, near Cienfuegos, will be of great interest to Louisiana planters. Mr. John O'Bourke, the administrator of this estate, has kindly given me a statement of last season's crop. This is the only house in Cuba employing an eight-roller mill.

THE MILL.

This may be termed a combination mill, consisting of four pairs of rolls of uniform length and diameter, and driven at the same periphery speed. The rolls are so arranged in a horizontal plane that the cane passes from one pair to the next without the use of a carrier, a narrow knife only being employed.

Dimensions.

	Length.	Diameter.
	<i>Inches.</i>	<i>Inches.</i>
Rolls.....	66	33
Journals.....	21	14

Periphery speed of rolls from 18 to 20 feet per minute. Maximum capacity of the mill, 30 tons of cane per hour.

The bagasse is saturated with live steam between the second and third, and third and fourth pairs of rolls.

The mill is double-gearred, fifteen to one, *i. e.*, fifteen revolutions of the engine to one of the rolls. The motive power is a pair of engines 21 inch cylinders and 41 inch stroke. The steam for the house is furnished by six boilers 40 by 6 feet; two flues. The milling machinery was built by Brissonneau, Frères & C^{ie}, of Nantes, France.

TREATMENT OF THE JUICE.

The juice is defecated in the usual manner. The clear juice is drawn off and is clarified by boiling and skimming. The sirup is boiled, as at Magnolia, in a high-pressure pan. The *masse cuite* falls directly into the mixer and is centrifugaled hot. Two molasses sugars are made.

Statistics of the crop of 1886.

Cane ground (2,000 pounds)	tons..	33,750.87
Juice extracted	per cent..	68.15
Sugars extracted	do	10.637
First sugar	do	7.534
Molasses sugar	do	3.103
Sugar made	pounds..	7,948,525
Sugar per ton of cane (2,000 pounds)	do	212.74

Unfortunately this house does not employ a chemist, consequently these figures are of but little value for comparison with those obtained at Magnolia.

The mangement of the Carolina estate should be congratulated upon the neatness and the sytematic working of the sugar-house.

CENTRAL SAN LINO.

Reports of a successful burner for bagasse led me to visit this estate.

The American planters are probably aware that the handling of the bagasse is a large item in the expenses of a Cuban estate. The bagasse is carted to the yard and spread out to dry. After drying it is carted back to the sugar-house and is deposited in front of the boilers. It requires a large force of firemen to handle this material.

At San Lino the green bagasse is handled in a different manner from the above, and is burned directly after leaving the mills. This method of burning bagasse is known as the "Sodal."

This invention consists in a plan for burning green bagasse or any other damp combustible. The combustion of the bagasse itself dries the fresh bagasse, which is fed to the fires from the end opposite to the grate bars. A very simple device is employed to carry the fuel to the fires. It requires ten minutes to transport the bagasse the length of boilers, in which time the flames passing over it evaporate a large proportion of the moisture.

The apparatus for charging the furnaces is driven by an independent engine and is perfectly automatic in its operations. This apparatus has reduced the number of laborers employed by about 150 men. In addition, the house is enabled to work in all kinds of weather now that it is not dependent upon the sun to dry its fuel. This process is especially applicable to large houses rolling thirty to forty or more tons of cane per hour.

Through courtesy of the owners, Messrs. Montalvo, and M. Boulanger, chemist of this house, I have obtained the following statistics, showing average of several seasons' work of this house.

Statistics of crops at San Lino.

	December.	January.	February.	March and April.
Extraction, per cent	71.50	70.90	70.29	69.80
Baumé	8.00	8.80	9.50	10.50
Brix	14.20	15.50	16.80	18.00
Sucrose, per cent.	11.50	13.02	15.09	16.75
Glucose, per cent.	1.45	1.10	0.70	0.65
Coefficient of purity	80.99	84.00	89.82	90.04
Glucose, per cent. sucrose	13.60	8.44	4.62	3.88
Masse cuite, per cent. cane	11.09	12.34	13.40	13.99
Yield of first sugar from masse cuite.	64.00	65.59	66.40	67.90
Yield of first sugar, per cent. cane	7.10	8.10	8.90	9.50
Yield of second sugar, per cent. cane	0.85	1.10	1.45	1.55
Polarization of first sugar	95.50	96.00	96.50	97.00

CENTRAL SUGAR-HOUSES.

The manufacture of sugar in Cuba is gradually being consolidated into large houses, the smaller estates furnishing the cane.

The Cuban manufacturers are beginning to realize what the Germans long since learned, viz, that it is more profitable for the sugar-house to attend to the manufacture only and leave the agriculture to tenants or independent farmers.

This system should be adopted by the planters of Louisiana. Our houses are too small to be worked economically. One house making 10,000,000 pounds of sugar can manufacture for a far smaller proportionate cost than three estates working three and a third millions each.

One of the owners of the largest houses in Cuba and probably the largest cane-sugar house in the world, told me that on the scale in which they manufacture (175,000 to 200,000 pounds per day) they make good profits even with the present prices. This house purchases its cane from tenants and independent farmers at a price dependent upon the average market value of sugar for each month. Hence, if the price of sugar rises, the cultivator profits by the rise; if it falls he divides the loss with the manufacturer. In these contracts, which are made for a term of years, it is specified that the density of the juice must not fall below a certain degree, but if it should, the manufacturer pays a lower price for the cane. The time of harvesting and the price to be paid for burnt cane in case of the fields being swept by fire also enter into these contracts.

THE ECONOMY OF STEAM.

The cost of fuel is a very large expense on Cuban estates, especially if this fuel is coal, which must be imported from other countries. The best houses employ every device for economy of combustible.

The evaporation is conducted in multiple-effect pans. The juice is pumped from the mill to a caloriser, consisting of a large number of tubes about which the vapors from the last pan of the system circulate,

and accomplishes a large proportion of the condensation. This is a very considerable economy. In the final concentration in the strike-pan exhaust steam at about five pounds pressure is employed.

I believe that the work at Magnolia could be done with a very largely reduced quantity of coal, and possibly with bagasse and a very little wood only, if these improvements were adopted. This would not include the bone-black department.

THE ANALYSIS OF SUGAR-CANE AND BEET-JUICES; WITH A TABLE FOR THE CALCULATION OF ANALYSES.

C. A. CRAMPTON.

In the routine work of cane- and beet-sugar houses the greater part consists in the analysis of large numbers of samples of juice. A method of manipulation for these analyses is therefore desirable, which will unite a reasonable degree of accuracy with considerable speed. The method and routine of analysis given below has been pursued by myself and others for several years in the work of the United States Department of Agriculture in its experiments on sorghum and sugar-cane, and found very expedient in the brief "sugar season," when the saving of time is so important an object.

For very accurate work, of course it is necessary to weigh out the sample of juice taken for analysis, but for all ordinary purposes the sample may be measured by volume, increasing greatly thereby the rapidity of the operation. By taking the specific gravity with accurate spindles, having their graduations well spaced, and correcting the volume taken, a very close approximation to the actual weight is obtained; this correction may be applied in two ways:

(1) By dividing the normal weight for the polariscope, or a multiple of it, by the specific gravity of the juice, to find the number of cubic centimeters of the liquid exactly corresponding to this weight, and then measuring out this quantity from a burette into a 100cc. flask, adding subacetate of lead solution, making up the volume to 100cc., filtering and polarizing. The reading of the polariscope gives directly the percentage of sugar in the juice, only multiplied by the number of times the normal weight was taken.

(2) By measuring out a certain volume of the juice, adding lead solution, making up to another definite volume, polarizing and applying the correction for specific gravity to the reading obtained.

I prefer the latter method as more expeditious and convenient, for in the other the specific gravity must be determined and the calculation made before the sample for polarization can be taken; while in the second method the specific gravity may be taken at any time through the day, and the calculation of the results postponed indefinitely.

The custom among sugar chemists in the beet-houses in France and Germany is to measure 100cc. of juice in a flask graduated to 100 and 110cc., add 10cc. of a dilute solution of subacetate of lead, filter, and polarize; the increase in volume being corrected either by reading in a 220mm. tube or by adding one tenth to the reading. I have found it more advantageous, however, to take 50cc. of the juice, add lead, and make the volume up to 100cc. This gives a much more satisfactory liquid for polarization, especially with impure juices, and the filtration is greatly facilitated. The only object attained by using 100cc. is the increase of the reading and consequent lessening of errors of observation. This is of but little importance, however, as 50cc. is three times the normal quantity for most instruments. Even this objection may be done away with by using a double length (400mm.) tube, providing the instrument used will admit of the long tube, and this is entirely practicable so far as the lucidity of the solution is concerned; for I have never failed to get clear, bright solutions by proceeding in the manner I have indicated, except in cases where juices had been allowed to stand and mucous fermentation had set in.

The detailed procedure is as follows:

Fifty cubic centimeters of the juice is measured out by means of an accurately calibrated pipette and run into a 100cc. flask; to it is added from 1 to 4cc. of a strong solution of sub-acetate of lead,¹ the whole made up to the mark with water, filtered, and polarized.

The same solution is then used for the determination of the reducing sugars by Fehling's solution, the excess of lead being precipitated by sulphate of soda. As the reduction of copper sub-oxide by sugars has been shown to be affected by the amount of dilution in which the action takes place, it is desirable to have as nearly as possible a constant amount of dilution, and the most favorable dilution is such that from 10 to 20cc. of the solution will be required to reduce the copper from 10cc. of Fehling's solution; so, for juice presumed to contain from 1 to 2 per cent. of reducing sugars, 50cc. of the solution, which has been polarized, made up to 100cc. will furnish the proper dilution; for those containing from 2 to 3 per cent., 50 to 100cc., and so on. In the case of juices containing less than 1 per cent. of reducing sugars the excess of lead may be removed by adding the sodic sulphate² before the lead precipitate is filtered off, when the same solution can be used for polarization and for the reducing-sugar determination. The copper solution used is Violette's modification, and the operation is performed in large test-tubes from 9 to 10 inches long and of about 1 to 1½-inch caliber, and the end reaction is obtained with ferrocyanide of potash and acetic acid, the small

¹ Prepared by rubbing up in a mortar 1 kilo of acetate of lead and ¼ kilo of litharge and boiling with ½ litre of water.

² For very exact work it is better to take a separate sample of the juice for the copper test and dispense with the lead altogether if the purity of the juice admits, for the presence of lead produces an error, and even when precipitated by sulphate of soda there is said to be an error from the slight solubility of the sulphate of lead.

portion of clear liquid required being filtered out by means of Wiley's tubes, already described.¹ These tubes are simply glass tubes about 9 to 10 inches long and $\frac{1}{4}$ -inch caliber. At one extremity a slight rim is made by turning back the edge while hot, and over this is stretched and tied a piece of fine linen cloth. To use the tube it is inserted into a beaker of water containing in suspension a quantity of very finely ground asbestos; by suction at the other end of the tube the linen cap is covered with a film of asbestos and it is then immediately inserted into the test-tube containing the hot precipitated Fehling solution; suction is again made on the tube and the portion of clear liquid obtained is run into a porcelain dish containing the test solution by simply inverting the tube. These tubes may be cleaned and used over and over again by washing off the asbestos film, dissolving out any sub-oxide of copper which may remain in the cloth by soaking in nitric acid and rinsing in water until they no longer taste acid. One covering of linen suffices for many tests, and when worn out it is easily replaced.

Working in this way a large number of samples can be analyzed in a day, twenty-five to thirty being generally a fair day's work for operators on the stations of the Department of Agriculture, both sucrose and glucose being determined, and also the total solids (from the specific gravity), and this number is much exceeded in case of stress of work by allowing the polarizations to stand until night, using all the daylight for glucose determinations. By having a boy measure out the samples and prepare them for analysis the amount of work done can be nearly doubled.

It remains to calculate the results obtained, and to facilitate this calculation I have compiled the following table. In it will be found the specific gravity and degree Brix,² and opposite to them factors for the calculation of sucrose and glucose in juices of the corresponding specific gravity, according to the method of procedure given above. Two factors for sucrose are given, one for instruments using as a normal quantity 26.048 grams, such as Soleil-Scheibler, and one for those using 16.3 grams, such as the Laurent. These factors are the quotients from division of the normal quantity by $50 \times \text{sp. gr.}$ To use them it is necessary simply to multiply by the reading of the polariscope, the result giving directly the per cent. of sucrose in the juice. The glucose factor is simply the reciprocal of the specific gravity multiplied by ten. To use it, it is divided by the number of cubic centimeters of the normal solution (50 to 100cc.) required to precipitate 10cc. of Fehling's solution, which gives the result directly in per cent. If the solution has been diluted twice (50 to 200cc.), divide the factor by half the number of cubic centimeters required; if one and one-half times (50 to 150cc.), by one and one-half times the number of cubic centimeters required.

¹ Bull. de l'Assoc. des Chim. de Sucre. et de Dist. Apr., 1884.

² Taken from the tables of Mateczek, Scheibler, and Stammer, as given by Dr. Tucker in his "Manual of Sugar Analysis."

Table for the calculation of sugar juices.

Specific gravity.	Degree Brix.	Sucrose factor for instruments requiring—		Glucose factor.	Specific gravity.	Degree Brix.	Sucrose factor for instruments requiring—		Glucose factor.
		26.048 grams.	16.3 grams.				26.048 grams.	16.3 grams.	
1.0197	5.0	.5109	.3197	9.807	1.0502	12.4	.4981	.3104	9.523
1.0201	5.1	.5107	.3196	9.803	1.0506	12.5	.4959	.3103	9.519
1.0205	5.2	.5105	.3195	9.799	1.0510	12.6	.4957	.3102	9.515
1.0209	5.3	.5103	.3193	9.795	1.0514	12.7	.4955	.3101	9.511
1.0213	5.4	.5101	.3192	9.791	1.0519	12.8	.4953	.3099	9.507
1.0217	5.5	.5099	.3191	9.788	1.0523	12.9	.4951	.3098	9.503
1.0221	5.6	.5097	.3190	9.784	1.0527	13.0	.4949	.3097	9.499
1.0225	5.7	.5095	.3189	9.780	1.0531	13.1	.4947	.3096	9.496
1.0229	5.8	.5093	.3187	9.776	1.0536	13.2	.4945	.3094	9.491
1.0233	5.9	.5091	.3186	9.772	1.0540	13.3	.4943	.3093	9.488
1.0237	6.0	.5089	.3185	9.768	1.0544	13.4	.4941	.3092	9.484
1.0241	6.1	.5087	.3184	9.765	1.0548	13.5	.4939	.3091	9.480
1.0245	6.2	.5085	.3183	9.761	1.0553	13.6	.4937	.3090	9.476
1.0249	6.3	.5083	.3182	9.757	1.0557	13.7	.4935	.3088	9.472
1.0253	6.4	.5081	.3181	9.753	1.0561	13.8	.4933	.3087	9.469
1.0257	6.5	.5079	.3180	9.749	1.0566	13.9	.4931	.3085	9.464
1.0261	6.6	.5077	.3178	9.746	1.0570	14.0	.4929	.3084	9.461
1.0265	6.7	.5075	.3177	9.742	1.0574	14.1	.4927	.3083	9.457
1.0269	6.8	.5073	.3175	9.738	1.0578	14.2	.4925	.3082	9.453
1.0273	6.9	.5071	.3174	9.734	1.0583	14.3	.4923	.3080	9.449
1.0277	7.0	.5069	.3173	9.730	1.0587	14.4	.4921	.3079	9.446
1.0281	7.1	.5067	.3171	9.727	1.0591	14.5	.4919	.3078	9.442
1.0286	7.2	.5065	.3170	9.723	1.0596	14.6	.4917	.3077	9.438
1.0290	7.3	.5063	.3169	9.719	1.0600	14.7	.4915	.3076	9.434
1.0294	7.4	.5061	.3167	9.715	1.0604	14.8	.4913	.3074	9.430
1.0298	7.5	.5059	.3166	9.711	1.0609	14.9	.4911	.3073	9.426
1.0302	7.6	.5057	.3164	9.707	1.0613	15.0	.4909	.3072	9.422
1.0306	7.7	.5055	.3163	9.703	1.0617	15.1	.4907	.3071	9.419
1.0310	7.8	.5053	.3162	9.699	1.0621	15.2	.4905	.3069	9.415
1.0314	7.9	.5051	.3160	9.696	1.0626	15.3	.4903	.3068	9.411
1.0318	8.0	.5049	.3159	9.692	1.0630	15.4	.4901	.3067	9.407
1.0322	8.1	.5047	.3158	9.688	1.0634	15.5	.4899	.3066	9.404
1.0327	8.2	.5045	.3157	9.684	1.0639	15.6	.4897	.3064	9.399
1.0331	8.3	.5043	.3156	9.680	1.0643	15.7	.4895	.3063	9.396
1.0335	8.4	.5041	.3154	9.676	1.0647	15.8	.4893	.3062	9.392
1.0339	8.5	.5039	.3153	9.672	1.0652	15.9	.4891	.3061	9.388
1.0343	8.6	.5037	.3152	9.668	1.0656	16.0	.4889	.3059	9.385
1.0347	8.7	.5035	.3151	9.665	1.0660	16.1	.4887	.3058	9.381
1.0351	8.8	.5033	.3150	9.661	1.0665	16.2	.4885	.3057	9.377
1.0355	8.9	.5031	.3148	9.657	1.0669	16.3	.4883	.3056	9.373
1.0359	9.0	.5029	.3147	9.653	1.0674	16.4	.4881	.3054	9.369
1.0364	9.1	.5027	.3146	9.649	1.0678	16.5	.4879	.3053	9.365
1.0368	9.2	.5025	.3144	9.645	1.0682	16.6	.4877	.3052	9.362
1.0372	9.3	.5023	.3143	9.641	1.0687	16.7	.4875	.3051	9.358
1.0376	9.4	.5021	.3142	9.638	1.0691	16.8	.4873	.3049	9.354
1.0380	9.5	.5019	.3141	9.634	1.0695	16.9	.4871	.3048	9.350
1.0384	9.6	.5017	.3140	9.630	1.0700	17.0	.4869	.3047	9.346
1.0388	9.7	.5015	.3138	9.626	1.0704	17.1	.4867	.3046	9.342
1.0393	9.8	.5013	.3137	9.622	1.0709	17.2	.4865	.3044	9.338
1.0397	9.9	.5011	.3136	9.618	1.0713	17.3	.4863	.3043	9.334
1.0401	10.0	.5009	.3134	9.614	1.0717	17.4	.4861	.3042	9.331
1.0405	10.1	.5007	.3133	9.611	1.0722	17.5	.4859	.3041	9.327
1.0409	10.2	.5005	.3132	9.607	1.0726	17.6	.4857	.3039	9.323
1.0413	10.3	.5003	.3131	9.603	1.0730	17.7	.4855	.3038	9.320
1.0418	10.4	.5001	.3129	9.599	1.0735	17.8	.4853	.3037	9.315
1.0422	10.5	.4999	.3128	9.595	1.0739	17.9	.4851	.3036	9.312
1.0426	10.6	.4997	.3127	9.591	1.0744	18.0	.4849	.3034	9.308
1.0430	10.7	.4995	.3126	9.588	1.0748	18.1	.4847	.3033	9.304
1.0434	10.8	.4993	.3125	9.584	1.0753	18.2	.4845	.3032	9.300
1.0439	10.9	.4991	.3123	9.580	1.0757	18.3	.4843	.3031	9.296
1.0443	11.0	.4989	.3122	9.576	1.0761	18.4	.4841	.3029	9.293
1.0447	11.1	.4987	.3121	9.572	1.0766	18.5	.4839	.3028	9.289
1.0451	11.2	.4985	.3119	9.568	1.0770	18.6	.4837	.3027	9.285
1.0455	11.3	.4983	.3118	9.565	1.0775	18.7	.4835	.3026	9.281
1.0459	11.4	.4981	.3117	9.561	1.0779	18.8	.4833	.3024	9.277
1.0464	11.5	.4979	.3115	9.557	1.0783	18.9	.4831	.3023	9.274
1.0468	11.6	.4977	.3114	9.553	1.0788	19.0	.4829	.3022	9.270
1.0472	11.7	.4975	.3113	9.549	1.0792	19.1	.4827	.3021	9.266
1.0476	11.8	.4973	.3112	9.545	1.0797	19.2	.4825	.3019	9.262
1.0481	11.9	.4971	.3110	9.541	1.0801	19.3	.4823	.3018	9.258
1.0485	12.0	.4969	.3109	9.537	1.0806	19.4	.4821	.3017	9.254
1.0489	12.1	.4967	.3108	9.534	1.0810	19.5	.4819	.3016	9.251
1.0493	12.2	.4965	.3107	9.530	1.0815	19.6	.4817	.3014	9.246
1.0497	12.3	.4963	.3106	9.527	1.0819	19.7	.4815	.3013	9.243

Table for the calculation of sugar juices—Continued.

Specific gravity.	Degree Brix.	Sucrose factor for instruments requiring—		Glucose factor.	Specific gravity.	Degree Brix.	Sucrose factor for instruments requiring—		Glucose factor.
		26.048 grams.	16.3 grams.				26.048 grams.	16.3 grams.	
1.0634	19.8	.4813	.3012	9.339	1.0914	21.8	.4773	.2967	9.163
1.0628	19.9	.4811	.3011	9.235	1.0918	21.9	.4772	.2986	9.159
1.0632	20.0	.4809	.3009	9.232	1.0928	22.0	.4769	.2984	9.155
1.0637	20.1	.4807	.3008	9.228	1.0927	22.1	.4768	.2983	9.151
1.0641	20.2	.4805	.3007	9.224	1.0932	22.2	.4765	.2982	9.148
1.0646	20.3	.4803	.3006	9.220	1.0936	22.3	.4764	.2981	9.144
1.0650	20.4	.4801	.3005	9.216	1.0941	22.4	.4762	.2980	9.140
1.0655	20.5	.4798	.3003	9.212	1.0945	22.5	.4760	.2979	9.137
1.0659	20.6	.4797	.3002	9.209	1.0950	22.6	.4758	.2977	9.132
1.0664	20.7	.4795	.3001	9.205	1.0954	22.7	.4756	.2976	9.129
1.0668	20.8	.4794	.3000	9.201	1.0959	22.8	.4754	.2974	9.125
1.0673	20.9	.4791	.2998	9.197	1.0964	22.9	.4752	.2973	9.121
1.0677	21.0	.4790	.2997	9.194	1.0968	23.0	.4750	.2972	9.117
1.0683	21.1	.4787	.2996	9.190	1.0973	23.1	.4748	.2971	9.113
1.0686	21.2	.4786	.2995	9.186	1.0977	23.2	.4746	.2970	9.110
1.0691	21.3	.4783	.2993	9.182	1.0982	23.3	.4744	.2968	9.106
1.0695	21.4	.4782	.2992	9.179	1.0986	23.4	.4742	.2967	9.102
1.0690	21.5	.4779	.2991	9.174	1.0991	23.5	.4740	.2966	9.098
1.0694	21.6	.4778	.2990	9.171	1.0996	23.6	.4738	.2965	9.094
1.0699	21.7	.4775	.2988	9.167	1.1100	23.7	.4736	.2963	9.091

458
27.5. Bureau of Agriculture
JAN 4 1905

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 16.

METHODS OF ANALYSIS

OF

Commercial Fertilizers, Feeding Stuffs, and Dairy Products

ADOPTED AT THE

FOURTH ANNUAL CONVENTION

OF THE

ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS,

AUGUST 16, 17, AND 18, 1887.

EDITED BY

CLIFFORD RICHARDSON,
SECRETARY.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1887.

5675 ANAL

LETTERS OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., September 10, 1887.

SIR: I have the honor to submit for your approval the proceedings of the Fourth Annual Convention of Official Agricultural Chemists, which met, by your invitation, at the Department of Agriculture on the 16th of August, this year.

The great advantage which scientific agriculture has received from the publication by the Department of the proceedings of the two preceding conventions leads me to believe that a similar benefit will be derived from the publication of the accompanying manuscript as Bulletin No. 16, of the Division of Chemistry of this Department.

I am, respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

WASHINGTON, *August 22, 1887.*

DEAR SIR: I have the honor to hand you for publication an abstract of the proceedings of the Fourth Annual Convention of Official Agricultural Chemists in the United States, together with the official methods adopted for the analysis of commercial fertilizers, feeding stuffs, and dairy products during the coming year. There is also appended a list of the committees appointed by the president for 1887-'88, of the officers of the Association, and a copy of the constitution as recently amended.

I have thought it desirable to curtail the somewhat discursive discussions as involving the publication of too large a bulletin and serious delay; in fact, being unable from the slender notes at my disposal to do justice to many of the speakers, the size of the meeting having grown beyond the possibility of reporting them without stenographic assistance. The essential points of each debate and the results are, however, given, I trust, with accuracy.

The increasing demand for our proceedings shows that the wisdom of the Department of Agriculture in disseminating them has been appreciated, and is laying the foundation for uniformity among official and commercial chemists, which is of the greatest value to the agricultural and business interests of the country.

The extension of the subjects considered by the Association, will, no doubt, vastly increase its sphere of usefulness.

Very respectfully,

CLIFFORD RICHARDSON,
Secretary.

Dr. H. W. WILEY,
Chemist.

UNIFORM METHODS FOR THE ANALYSIS OF FERTILIZERS, FEEDING STUFFS, AND DAIRY PRODUCTS.

PROCEEDINGS OF THE FOURTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, HELD AT WASHINGTON, AUGUST 16, 17, AND 18, 1887.

MORNING SESSION, TUESDAY.

In accordance with the call of the executive committee, the Association met in the library of the Department of Agriculture at 10 o'clock, the president, Dr. E. H. Jenkins, in the chair.

The following members and "others interested in the objects of the Association" were present:

The President—Dr. E. H. Jenkins, of the Connecticut Agricultural Experiment Station.

The Vice-President—Mr. P. E. Chazal, State chemist of South Carolina.

Of the Executive Committee—Prof. M. A. Scovell, director of the Kentucky Agricultural Experiment Station and State chemist, and Dr. H. W. Wiley, chemist of the U. S. Department of Agriculture.

The Secretary—Mr. Clifford Richardson, of Washington, D. C.

Dr. William McMurtrie, of Champaign, Ill.

Dr. W. J. Gascoyne, of Richmond, Va.

Dr. S. M. Babcock, of Geneva, N. Y.

Prof. G. S. Fellows, of Agricultural College, Maryland.

Prof. William Frear, of State College, Pennsylvania.

Dr. E. A. v. Schweinitz, of Lexington, Ky.

Prof. Frank T. Shutt, of Ottawa, Canada.

Dr. Milton Whitney, of Raleigh, N. C.

Dr. Thomas Macfarlane, of Ottawa, Canada.

Dr. G. C. Caldwell, of Ithaca, N. Y.

Dr. E. H. Farrington, of New Haven, Conn.

Prof. W. C. Stubbs, of Baton Rouge, La.

Prof. W. E. Moses, of Knoxville, Tenn.

Prof. C. E. Waite, of Rolla, Mo.

Prof. N. W. Lord, of Columbus, Ohio.

Prof. J. A. Myers, of Agricultural College, Mississippi.

Prof. N. T. Lupton, of Auburn, Ala.

Prof. W. B. Rising, of Berkeley, Cal.

Prof. Robert B. Warder, of La Fayette, Ind.

Prof. Edgar Richards, of Washington, D. C.

Prof. Fred A. Holton, of Kansas City, Mo.

Prof. Charles E. Bond, of Spencerville, Md.

Prof. Charles A. Crampton, of Washington, D. C.

Prof. Arthur L. Green, of La Fayette, Ind.

Mr. A. E. Knorr, Mr. N. J. Fake, Mr. F. V. Broadbent, Mr. Felix Langfeldt, Mr. John Dugan, of the U. S. Department of Agriculture.

Mr. de Ghequier, representing the interests of the National Fertilizer Association.

Letters of regret were read from many prominent gentlemen who were unable to be present.

In calling the convention to order the president spoke as follows:

GENTLEMEN OF THE ASSOCIATION: We begin to day the fourth annual meeting of this Association. It is the eighth meeting of American agricultural chemists for the discussion of methods of analysis. In consequence of the enlargement of the scope of our discussions we hope that there will be a considerable addition to our numbers at this time, and that in consequence the Association, which has already proved itself to be of very great value both to its members and to producers and consumers of fertilizers as well, will become of even greater value in these particulars, and also in other respects, to all who are personally engaged in agricultural chemical research.

In opening the meeting I wish to call attention to one or two particulars in regard to the constitution of this Association, with the object of preventing any misapprehension on the part of new members of the Association, and which we all need to keep clearly and constantly in mind.

First, then, this is an Association of analysts in a special department of chemistry. It is primarily *agricultural* chemical methods and processes which are for discussion here, not other departments of agricultural or chemical investigation. Yet we cannot draw any very rigid line between them. For instance, the availability of the different forms of phosphoric acid is an agricultural question and a chemical question, but taken by itself would hardly concern us, and experiments on the subject would more properly be presented and discussed elsewhere than here.

But Wagner's vegetation experiments on the subject in connection with his method of determining available phosphoric acid in the laboratory, the results of which are designed to coincide with the results of vegetation experiments, would seem to bring this matter within the scope of our discussions in so far—but only so far—as they might influence us in fixing a method for determining available phosphoric acid.

It is to cover such cases as this that the second object of the Association is declared to be "to afford opportunity for the discussion of matters of interest to agricultural chemists."

Again, as to membership. The Association is for the use of all those who are engaged in agricultural investigation and experiment, or who are charged with official duties in the examination of fertilizers, foods, &c. The membership is limited to persons of these two classes.

I call attention to the fact that the wording of the second clause of our constitution is rather ambiguous, and might be so interpreted as to exclude some who belong in the classes above named. The clause in question reads:

Analytical chemists connected with departments of agriculture, agricultural experiment stations, agricultural colleges, State boards of agriculture, and other bodies charged with official control of the materials named in section 1 shall alone be eligible, &c.

Now this may be interpreted to exclude chemists from agricultural colleges which do not exercise any *official* control over the articles named in section 1. Such an interpretation, I am sure, was not intended, and the Association may see fit to change this, either by inserting after "agricultural colleges" the words "and chemists of," or else by making the section read:

Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with an official control of the materials named in section 1, &c.

This last form would include the chemists of the Treasury Department who are appointed under the national law regulating the sale of oleo-margarine.

The provision that only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers, may, at first thought, seem rather unfair, but a little consideration will, I am sure, commend it to the judgment of our new members. The official chemists are responsible to their governing boards, to the manufacturers and the consumers alike; large financial interests are involved, and it is no more than fair that having these responsibilities, they alone should have the decision as to the methods they shall use. The necessity for this was apparent after the Cincinnati meeting of "agricultural chemists," prior to the organization of this Association, where of thirty-two members in attendance only nine at most (probably fewer) had any official connection with fertilizer control, and where a method was adopted as "official" which was promptly repudiated by official chemists.

None the less all the assistance that can be rendered by study and discussion on the part of other members of the Association and other chemists who may be present is most desirable, and in past years has been very helpful. It should be added that the National Fertilizer Exchange, representing the fertilizer manufacturers' interest, through its

secretary, Mr. D'Ghequier, has expressed itself as well satisfied with the present plan of fixing methods of fertilizer analysis.

On the conclusion of the president's address the recommendation of the executive committee that the following should be the order of business for this meeting was unanimously agreed to:

(1) Reports of committees: (a) On Cattle Foods; (b) on Dairy Products; (c) on Phosphoric Acid; (d) on Potash; (e) on Nitrogen.

(2) Election of officers and miscellaneous business.

In accordance therewith Dr. G. C. CALDWELL, on behalf of the Committee on Cattle Foods, submitted the following report:

REPORT OF THE COMMITTEE ON THE ANALYSIS OF CATTLE FOODS.

The Committee on the Analysis of Cattle Foods submit the following report:

Fifteen chemists connected with experiment stations or agricultural colleges consented to make analyses of samples of fodder to be prepared and sent out by the committee—some of them, however, conditionally, being uncertain whether they would have time for the work. Reports were received from ten of the number on the three samples sent out.

These samples were hay, bran, and cotton-seed meal. The first was cut up and ground in a large coffee mill, and then very carefully mixed by stirring over with the hands on a large sheet of paper. The other samples were mixed as much as seemed to be necessary to make them uniform in composition. It was assumed, however, that but little preparation of these stuffs was necessary. The portions for each chemist were taken from the dish containing the whole of the mixed sample by means of a large spoon plunged into the mass, and not by pouring.

Each analyst was requested to follow such methods of analysis as he preferred, but to give the committee full information as to the details of the methods used, either directly or by reference to generally accessible authorities.

The results returned are given in the following table, calculated to water-free substance.

[All results calculated to water-free substance.]

	Cotton-seed meal.					Wheat bran.					Hay.				
	Ash.	Protein.	Ether extract.	Fiber.	Nitrogen free extract.	Ash.	Protein.	Ether extract.	Fiber.	Nitrogen free extract.	Ash.	Protein.	Ether extract.	Fiber.	Nitrogen free extract.
	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
Babcock	7.37	52.26	10.60	6.42	23.41	7.17	16.84	4.69	11.65	59.65	5.25	8.72	3.23	33.49	49.81
Caldwell	7.33	51.29	11.13			7.20	15.97	8.34	10.95	62.54	5.49	9.88	3.62	32.22	49.29
Frear	7.76	44.78	10.95	4.09	32.42	7.46	15.87	4.97	8.30	63.90	6.81	11.48	3.67	26.99	51.55
Jordan	7.38	52.61	10.90	6.65	22.46	7.36	17.43	4.42	10.46	60.89	5.73	9.04	3.59	29.93	51.91
Lupton	7.28	50.04	11.87	6.44	24.37	6.83	17.00	3.90	13.36	58.91	5.64	8.32	3.13	33.12	49.79
McMurtree	6.89		8.89	9.20	27.69						7.41	11.59	1.85	32.69	45.99
Richardson	7.44	50.70	12.23	5.07	24.55	7.74	16.45	6.50	6.91	62.40	5.55	8.79	5.36	25.97	54.33
Scovell	7.44	51.80	10.57	3.71	26.48	7.33	16.93	2.84	7.39	65.51	5.81	8.95	4.07	26.03	53.14
Warder	7.43	52.73	12.32		27.51	7.29	17.17	5.83		69.78	5.06	8.56	5.61		79.38
Weber	7.51	51.60	10.53	5.95	24.41	7.36	17.01	4.85	10.66	60.12	5.63	9.41	3.21	32.13	49.62

* Direct.

Total and album. N. in dry substance.

	Cotton-seed meal.		Bran.		Hay.	
	Total.	Album.	Total.	Album.	Total.	Album.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
C	8.21	8.00	2.56	2.32	1.50	0.95
B	8.34	7.9	2.70	2.10	1.39	1.21
F	7.16	7.14	2.54	2.23	1.83	1.60
M					1.68	1.68
R					1.40	1.40

In view of the general similarity in the methods of analysis employed, and, it might be added, necessarily employed, the serious divergence in the results obtained by different chemists on the same sample is rather startling and calls urgently for further work in this direction.

With regard to the ash the results agree so well, with but a very few exceptions, that this part of the subject seems to need but little further treatment, and yet even here the difference between the highest and the lowest per cent. on bran is nearly 0.9 per cent. The difference can hardly be ascribed to want of uniformity in the sample, for a peck of it could reasonably be supposed to be practically uniform in composition even as brought from the mill; so between the highest and lowest ash in hay the difference is a little over 2 per cent., or, leaving out the case in which the work was reported as being done by an advanced student in the laboratory, we have a maximum difference of 1.3 per cent. In spite of the precautions taken to secure perfect uniformity of the sample, this difference may be explained by imperfect mixing. The highest ash obtained, still making the exception above referred to of the extremely high result, was, with both cotton-seed meal and hay, with the use of an alcohol lamp instead of gas. The lowest ash in cotton-seed meal and the highest of all on hay was obtained by charring, exhausting with water, burning the residue of coal, and adding this ash to the residue left on evaporation of the aqueous extract.

With regard to the protein, when it is considered that the quantity of substance taken for analysis is necessarily small, and that even after calculating the percentage on nitrogen from the small quantity we have still to multiply by 6.25 for the final result, the results in the main agree as well as could be expected. The agreement is closest on the cotton-seed meal, excluding one report so far out as to indicate some mistake, next best on the bran, and by far the poorest on the hay.

The nitrogen was determined by some after Kjeldahl, by others by soda lime, and in one case after Ruffie; but no uniform difference in results corresponds with different methods. Apparently only in more careful preparation of the sample or more scrupulously careful work in the analyses can we hope for improvement in results on the protein.

Ether extract.—Here we have but a single operation of the simplest character, performed in the same general manner, and the product to be determined is itself weighed; and yet the results reported differ by as much as 2 per cent. on an average total of only 3 to 4 per cent. Some of the chemists used Squibbs (stronger) ether, others ordinary washed ether. Most of them appear to have used Soxhlet's self-siphoning extractor, others used an ordinary continuous.

One, and perhaps more, have used the same sample for the determination of moisture and of ether extract. Dr. Babcock has found that long-continued desiccation appears to lessen the solubility of the fat in ether (2nd Rep. N. Y. Exp. Sta., 1883), but this was proved only for drying at 100° for several (7) days and upward.

The duration of the time of extraction varied from a few hours to three or four days. In many cases nothing is stated as to tests for complete extraction, or as to the time of extraction.

One chemist, who reported the lowest results on bran, but on this sample only, subsequently, in a supplementary report detailing results of experiments on time of extraction, obtained by a much longer extraction, extending over some days of alternate simple contact with the ether in a self-siphoning apparatus and extraction by boiling, instead of eight hours as before, gives results on bran nearly on a par with the others, but no higher results on hay. Another, who reports much the highest results on cotton-seed meal and hay, states that from three to four days were required for complete extraction. Another (R), who gave treatment for twelve hours in a self-siphoning apparatus, reports very much the highest results on bran, and only a little less than W. on the other samples.

There appears to your committee to be ground for the hope that, by uniformity in the details of the method of carrying out this determination, much greater uniformity in results can be secured. This uniformity should refer particularly to the previous treatment of the sample, the kind of ether used, and the time of extraction. Whether the form of apparatus—that is, whether of the intermittent or continuous class—is of importance is uncertain.

The crude fiber.—Doubtless all who have taken part in this work of testing methods of analysis of feeding stuffs, expected wide divergence in results in the fiber, and certainly these expectations are not disappointed. Leaving out the results reported by one chemist on cotton-seed meal, which were not obtained by himself, but by an advanced student in his laboratory, and which differ so very much from the general average as to justify their exclusion, the results on cotton-seed meal range from 3.7 to 6.44; on bran, 2.84 to 5.83; and on hay, from 25.97 to 33.49.

The method followed was essentially the same in all cases, boiling with dilute acid of a certain strength for a certain time (thirty minutes), filtering, and washing; boiling with alkaline solution of a certain strength for the same length of time; washing with hot water, alcohol, and ether, drying, and weighing, and incineration, the loss of weight by this last operation giving the crude fiber. In general the same strength of acid and alkaline solution (1.25 per cent.) was used by all the analysts, but not in all cases, and in some instances the strength is not given. The boiling was in general, so far as stated, continued for the same length of time. In some cases the fat was previously extracted, in others not; presumably in all cases the residue finally obtained was incinerated, but it is not always so stated. There is much variation in the amount of substance taken, ranging from 1 to 4 grams, while the quantity of acid and alkali used remains the same, and generally speaking with the smaller quantity of substance taken the per cent. of fiber is smaller, but this is not uniformly the case.

No invariable difference depends upon whether the fat is previously extracted or not, so far as can be judged with reference to the few cases in which information is given on this point.

This matter of the determination of fiber in fodder has been made the subject of special investigation at more than one experiment station.

Krauch ("Bestimmung der Holzfaser und ihrer Mangel," Vers. Stat., XXV, 1880, p. 240) made a careful study of the residue left after treatment of the material with ether, alcohol, cold and warm water, and malt (Malzaufguss) which was then supposed to be free from fat, wax, chlorophyll, and carbohydrates. This residue was supposed to consist essentially of cellulose and lignine, with insoluble N. substance. It was prepared from three different feeding stuffs—rye (grain), graminaceous hay, and clover, and each residue was subjected to treatment with dilute acid and alkali successively and with Schulze's reagent, whose method, the author says, is the best for the preparation and determination of cellulose; but it often fails (im Sticke lässt) and is so difficult and tedious of execution as to be inapplicable to fodder analyses. Not getting constant results by this treatment of the residue with acid, alkali, &c., the author concludes that it varies so much in composition when prepared from different feeding stuffs as to indicate that the same treatment will not answer for all kinds for the

separation of cellulose from lignine, or, in other words, that the method of determining fiber must be varied somewhat according to the general character of the material analyzed. This is the special light he gives us on the matter.

Hofmeister ("Die Rohfaserbestimmung und das Holzgummi," Vers. Stat., XXXIII. 1886, p. 152) comes to the same conclusion even in comparing material so much alike as different kinds of oil cake, and still more when comparing bran with these. He says that in the ordinary method of determining crude fiber, matters may be left undissolved and reckoned as fiber which are not so left in the case of other stuffs.

But these investigations, while showing up some sources of inaccuracy of the ordinary determinations of fiber, give us no help in our search for a solution of the problem now in hand—how different analysts working on the same sample may get results agreeing so well together that we can have some degree of confidence in the method used.

Mr. Ladd ("Crude Fiber in Fodder Analysis," 5th Report New York Ag'l Exp., Sta., p. 374) gives the results of a comparison of five or six different methods of managing the treatment with acid and alkali, and finds a decided difference in the probable error by different methods, the method followed at that station having the lowest; but, after all, this may have been because it was a method with all of whose details he was thoroughly familiar by long practice.

Only five of the chemists made the determination of non-albuminoid nitrogen by Stutzer's method. The results are given in the following table:

	Cotton-seed meal.		Bran.		Hay.	
	Total.	Albumen.	Total.	Albumen.	Total.	Albumen.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
C.....	8.21	8.00	2.56	2.32	1.60	0.95
B.....	8.34	7.9	2.70	2.10	1.39	1.21
F.....	7.16	7.14	2.54	2.23	1.63	1.60
R.....					1.395	1.395
M.....					1.68	1.65

While there is in the main a fair measure of agreement between these results on the same sample, still there are differences that ought not to occur with reliable methods and good work.

RECOMMENDATION.

Ash.—None except extraction.

Ether extract.—Ether of uniform strength (Squibb's stronger), pulverization of substance to uniform standard, longer time of extraction than generally given—twelve hours at least.

Crude protein.—Kjeldahl's method and greater care in working, guarded by blank determinations to test material.

Fiber.—Exactly uniform strength of acid and alkali, time and temperature of treatment, agitation, previous extraction of the fat.

G. C. CALDWELL,

Chairman.

CLIFFORD RICHARDSON,

Of the Committee on Feeding Stuffs.

The report being open for discussion, Mr. RICHARDSON said that as one of the committee he desired to suggest digestion in bottles closed by patent rubber stoppers for the determination of crude fiber, using somewhat stronger re-agents and a water bath as a source of heat. He was of the opinion that uniformity might be more nearly reached in this way.

After considerable discussion he was authorized to make the method as described, an alternate with the original Weende, for official use during the ensuing year.*

Professor CALDWELL then drew attention to the direct determination of N. free extract as practiced by one of the Association.

Dr McMURTRIE said that the method was to invert with acid after extraction, and titrate with Fehling's solution.

Attention was then called to the differences caused on fiber determinations by the degree of pulverization of the sample, the indifferent use of potash and soda, the effect of different elevation on the boiling point, the amount of material, and whether or not previous extraction was practiced. These points were referred to the committee for consideration, which, on motion of Professor Caldwell, was completed by the addition of Dr. Babcock to fill the vacancy caused by Dr. Jordan's absence.

Some discussion then ensued in regard to the determination of fat, the quality of the ether employed, form of apparatus, time of extraction, and benefit of previous drying, all of which, the report having been recommitted, the committee were directed to consider and to report to the convention at some time during the session the methods to be recommended for the ensuing year.

By unanimous consent it was then carried that a committee should be appointed to consider the recommendations of the president in regard to changes in the constitution, to consist of four members and the president *ex-officio* as chairman, and a committee of three to wait upon the Commissioner of Agriculture and request him to address the convention and to thank him for his courtesies.

The chair appointed—

To wait upon the Commissioner, Professors McMurtrie, Stubbs, and Gascoyne;

To consider changes in the constitution, the president *ex officio*, Drs. Chazal, Myers, Gascoyne, and Stubbs.

The chairman then welcomed to the convention the visiting chemists, Professor Macfarlane, chief analyst of the Dominion, and Professor Shutt, of the experimental farm at Ottawa.

The convention then listened to the report of the committee on dairy products, Dr. Wiley announcing that, having prepared it himself, his colleagues on the committee were in no way responsible for the suggestions it contained.

REPORT OF THE COMMITTEE ON DAIRY PRODUCTS.

As chairman of the committee on "dairy products," I beg leave to submit the following report:

In the beginning of an investigation by the Association of dairy products, it appeared to me that the most important point to be considered was the possibility of agreeing upon uniform methods of analysis. The success which has attended our ef-

* The details are to be found among methods in Appendix A.

forts in this respect with commercial fertilizers has been great enough to encourage us in hoping for a like advantage in other fields of investigation.

The members of the committee being widely scattered, it was found impracticable to secure a meeting to discuss the "plan of campaign" and agree upon a line of investigation. In this condition of affairs I took the liberty, as chairman of the committee, to inaugurate a preliminary examination of methods of butter analysis and of inviting my confrères to undertake other parts of the investigation.

In order to obtain an expression of the views of the other members of the committee, namely, Drs. Armaby and Babcock, I addressed them the following letter:

"FEBRUARY 19, 1887.

"As chairman of the committee on dairy products, I write to ask your advice respecting the work we ought to do in the way of preparing something for the next meeting. I propose to send a letter to each of the active members asking him if he will make analyses of four samples of butter and butter substitutes which I will send.

"What part of the report to the convention will you prepare? Take some subject and work it out.

"Please let me hear from you soon."

To this I received the following courteous replies:

"MADISON, WIS., *February 23, 1887.*

"DEAR SIR: The committee on dairy products labors under a disadvantage as compared with the other committees in not being able to send around samples to any extent. The only way I see now is, as you suggest, for each member of the committee to take some subject, work it up as fully as may be. Our assistant chemist is now doing some work on butter analysis, and has done considerable in that line, so that I might be able to contribute something on that subject. However, I will take up anything you may desire that I think I can do anything like justice to.

"Is it your idea to include in the report any extended discussion?

"I think your proposal to send around samples of butter and butter substitutes for analysis an excellent one, and I will do my share.

"Yours truly,

"H. P. ARMSBY."

"GENEVA, N. Y., *March 2, 1887.*

"DEAR SIR: Your letter of February 19, in relation to work of the committee on dairy products, came when I was away from the station, or it would have been answered before this.

"I shall be glad to make analyses of any samples of butter or butter substitutes which you may send.

"I shall be working most of the summer upon milk and butter, and would prefer to prepare something in this line for the report. If you have any choice as to what points I shall devote especial attention to, please let me know and I will endeavor to attend to it.

"Very truly yours,

"S. M. BABCOCK."

On the receipt of these letters I sent the following circular letter to members of the association and others whom I thought would be interested in the matter:

"WASHINGTON, D. C., *February 21, 1887.*

"DEAR SIR: As chairman of the committee of the A. O. A. C. on dairy products, I am ready to send out some samples of butters for comparative examination. The distribution of samples of milk is of course impossible, and I propose, therefore, to send three or four samples of butter and butter substitutes. I do not think a larger

number of samples would be advisable on account of the great amount of analytical work which they would require.

"Please let me know if you wish a set of four samples sent you. If so, they will be forwarded within a few days after receiving your reply.

"Respectfully,

"H. W. WILEY,

"*Chairman Committee A. O. A. C. on Dairy Products.*"

The following chemists expressed a willingness to undertake the analyses, viz :

Name.	Address.
Lupton, Prof. N. T.	Auburn, Ala.
Johnson, Prof. S. W.	New Haven, Conn.
White, Prof. H. C.	Atlanta, Ga.
McMurtre, Prof. Wm.	Champaign, Ill.
Huston, Prof. H. A.	Lafayette, Ind.
Jordan, Prof. W. H.	Orono, Me.
Kedzie, Prof. R. C.	Agricultural College, Mich.
Babcock, Dr. S. M.	New York Agricultural Experiment Station, Geneva, N. Y.
Caldwell, Prof. G. C.	Ithaca, N. Y.
Stillwell, Chas. M.	New York, N. Y.
Frear, Dr. Wm.	State College, Pa.
Moses, Prof. W. E.	Knoxville, Tenn.
Traphagen, Mr. F. W.	Staunton, Va.
Cooke, Prof. W. W.	Burlington, Vt.
Armsby, Dr. H. P.	Madison, Wis.

EXAMINATION OF BUTTER.

It being impossible to secure analyses in the way of milk samples, I prepared samples of butter and butter substitutes and sent them to the above addresses.

The samples were purchased in the open market at Washington and consisted of the following items:

No. 1.—Oleomargarine, at 20 cents per pound.

No. 2.—Butterine, at 20 cents per pound.

No. 3.—Butter, at 20 cents per pound.

No. 4.—Philadelphia print butter, at 60 cents per pound.

The samples were carefully packed in tin boxes and sent by mail. Accompanying these samples was the following letter:

"WASHINGTON, D. C., April 12, 1887.

"SIR: On behalf of the committee on dairy products I send you by mail this day four samples of butter and butter substitutes, and beg you to submit them to an examination.

"The examination should, if possible, comprise the following points:

"(1) A microscopic examination of a portion of the sample with polarized light and a selenite plate.

"(2) A further microscopic examination of the sample after boiling for a few moments in a test tube until the water is expelled and subsequently cooling slowly and allowing to stand for 24-48 hours.

"(3) A determination of the Sp. Gr. of the filtered and dried sample.

"(4) A determination of the melting point of the filtered fat.

"(5) A determination of the volatile acid in the filtered fat according to the principle of Reichert.

"(6) A determination of the insoluble acids in the filtered fats after washing out all that is soluble.

"(7) A determination of the saponification equivalent according to the method of Koettstorfer.

"(8) A determination of the percentage of moisture.

"(9) A determination of the percentage of salt.

"(10) A determination of the per cent. of curd.

"Since butters are apt to change in character on long keeping, I desire to urge upon you the necessity of finishing this analytical work promptly.

"When the work is completed please send the results to me for tabulation according to the usage of the association.

"Any modification or change in the methods of analysis employed, from those in general use, should be noted.

"I also desire to have all analysts engaged in this work to send me at an early date any notes or suggestions which may seem of interest for the report to be made at the next meeting of the association.

"Respectfully,

"H. W. WILEY,

"Chairman Committee on Dairy Products A. O. A. C."

RESULTS OF THE COMPARATIVE ANALYSIS OF BUTTER SAMPLES.

I give below in tabular form the results of the analyses of butter, comprising all the returns that have been received from the samples sent.

Following the custom of the association, I have designated the different returns by the letters of the alphabet.

In no case has any one analyst extended his examinations to all the points suggested in the circular. The results of analyst A, however, embrace all the points mentioned but one. This omission is compensated for, however, by a study of the viscosity of the samples.

Analyst.	Polarized light and selenite plate.	Polarized light and crystallized fat.	Specific gravity.	Melting point.	Volatile acids, Reichert's method, No. cc. 10 alkali.	Soluble acids.	Insoluble acids.	Saponification equivalent.	Water.	Salt.	Curd.
Sample No. 1.											
A	Colors variegated.	Cross well defined.	.905	32.0	P. et. .60	P. et. .60	P. et. 93.78	287.2	P. et. 7.72	P. et. 2.12	P. et. .47
B			.9079	32.2	.38		91.26	283.0	7.18	2.18	1.11
C			.9001		.60				6.30		
D			.9063	33.6*				280.8	7.12	2.11	1.48
E			.9063			.22	95.25		6.25	2.11	1.00
F					2.24		95.17	275.8	6.54	1.82	.60
G					.31	.21	94.61				
H	Variegated field.		.9080	31.8	0.40			281.0	6.49	1.99	.34
Sample No. 2.											
A	Colors variegated.	Large cross	.9041	39.5	0.90		94.45	288.5	7.50	2.11	.27
B			.9071	33.3	.29	1.19	93.40	287.0	8.06	2.21	.98
C			.8589		.50				6.60		
D			.9058	41.5				283.1	7.63	2.11	1.47
E			.9038		3.90	0.10	95.90		6.78	1.88	2.34
F							96.13	263.0	6.89	1.99	
G					.30	.54	94.10				
H	Variegated field.		.9046	40.1	0.40			288.7	6.64	2.11	.58
Sample No. 3.											
A	Color nearly uniform.	Small cross like No. 1.	.9087	35.0	12.30		85.44	250.4	11.06	5.11	.65
B			.9121	28.3	12.35	5.56	84.29	249.0	10.25	4.05	1.44
C			.8623		12.70				10.30		
D			.9088	36.0				247.7	10.06	4.45	3.70
E			.9088			4.95	89.03		10.51	3.86	3.41
F					13.43		90.09	241.2	10.37	4.53	.41
G					13.13	4.48	87.21				
H	Uniform tint.		.9091	34.5	13.06			244.0	8.97	4.56	.78

* At 100° C.

Results of the comparative analysis of butter samples.—Continued.

Analyst.	Polarized light and sclenite-plate.	Polarized light and crystallized fat.	Specific gravity.	Melting point.	Volatile acids, Reichert's method, No. cc. to alkali.	Soluble acids.	Insoluble acids.	Saponification equivalent.	Water.	Salt.	Curd.
<i>Sample No. 4.</i>											
A	Color uniform.	Crystals, large cross.	.9114	34.4	P. ct. 14.4	P. ct.	P. ct. 87.06	249.0	P. ct. 10.95	P. ct. 1.00	P. ct. .65
B			.9137	28.6	14.31	5.75	83.37	250.0	11.36	.87	1.34
C			.8645		14.80				9.80		
D			.9105	35.4				244.5	10.86	.87	1.79
E			.9110			5.81	86.94		8.21	.79	1.83
F					15.75		88.60	230.9	11.03	.86	
G					15.90	5.73	87.43				
H	Uniform tint.		.9109	33.0	15.39			248.0	8.44	.79	.64

SUPEREROGATORY ANALYSES.

In two instances, viz, A and H, the analyses were pushed further than was asked for in the circular letter already quoted.

The viscosity of the soap solutions made from the fats of the samples was determined by Analyst A.

Following are his results:

Sample.	
No. 1	Too viscous to test.
No. 2	Do.
No. 3	Viscosity = 173.
No. 4	Viscosity = 109.

The determination in each case was made with 15 grams filtered fat and 10 grams KOH, the volume being made up to 500 cc. with water.

The soaps from Samples 1 and 2 gave solutions too viscous to be determined by the apparatus as arranged. This means a viscosity exceeding 1,000 on the scale adopted.

IODINE ABSORPTION.

The iodine absorption of the several samples was determined by Analyst H. Following are the percentages of iodine absorbed.

The determinations were in quadruplicate.

Number of determination.	Iodine absorbed.			
	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
No. 1	Per cent. 63.23	58.28	37.81	21.15
No. 2	63.28	58.57	37.67	20.98
No. 3	64.01	58.54	37.79	20.89
No. 4	63.93	58.22	37.59	20.85
Mean	63.61	58.40	37.72	20.97

METHODS OF ANALYSIS EMPLOYED.

In the absence of any method of examination agreed upon by the members of the association each analyst was left free to follow that process which seemed to him best.

Complying with the request of the circular letter, however, a brief sketch of the methods employed accompanied most of the returns received.

DESCRIPTION OF METHODS OF ANALYSIS.

Following is a recapitulation of the several schemes of analysis that were pursued:

Analyst A.—The specific gravity was determined at 40° C. by weight in a specific-gravity bottle. The melting points were found by Wiley's method. The volatile and insoluble acids and the saponification equivalent were determined in the usual manner. The moisture, salt, and curd were found by methods described in New York Agricultural Experiment Station report for 1886, the salt being considered the same as ash, and the curd calculated from nitrogen.

Analyst B.—Specific gravity of filtered fat determined by a 10 cc. specific-gravity bottle at 37°·7 C., according to directions given by Blyth (see Blyth, *Foods Composition and Analysis*, London, 1882, p. 295); duplicate determinations made.

"Melting point of butter fat determined by a small glass bulb weighted with mercury (*loc. cit.*, p. 294). Weight of bulb, 3.7806 grams. Temperature noted at the point when the bulb sank just below the surface of the fat in the test tube (diameter of test tube 1 inch).

"Reichert's method: As nearly 2.5 grams of the filtered fat as possible were weighed into a 4-ounce flask while in a fluid state. Twenty cubic centimeters of alcohol (80 per cent.) and about 1 gram of solid KOH were added; the flask was heated on water bath till the air sucked out of it no longer smelled of alcohol; 50 cc. of water were then added, and when the soap was wholly dissolved, 20 cc. of sulphuric acid (1-10). Two pieces of pumice stone attached to short platinum spirals were used to prevent bumping in distilling. The distillate was passed through a small wet filter into a 50 cc. flask; the first 20 cc. of distillate being poured back if found necessary, and was titrated with decinormal soda solution, using phenolphthalein as an indicator; duplicate determinations being made, and 0.07 cc. of NaOH sol., being required by blank test, always deducted from results.

"Hehner's method: Carried on as directed by Blyth (*loc. cit.* 296); to about 4 grams of fat weighed out in a 4-ounce flask, 50 cc. of semi-normal alcoholic solution of potash were added; flask covered with a small watch glass, and heated slowly till all fat saponified; watch glass then removed and alcohol evaporated; when wholly free from alcohol, soap dissolved in about 50 cc. of water, solution transferred to a 500 cc. flask; soap decomposed with semi-normal H²SO₄ and insoluble fatty acids washed as directed. Only single determinations made."

As will be seen, results are all lower than usually given, both in case of samples of butter and of butterine. Analysis of samples made in spring, 1886, with other solutions showed similar results, as will be seen from the following table:

Sation No.	Insoluble acids.	Soluble acids.	Sum.	Pure butter.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Pr. ct.</i>	<i>Per cent.</i>
1.....	86.09	4.48	90.97	100
3.....	86.01	5.27	91.22	100
8.....	96.02	.75	96.77	(*)
14.....	90.52	.00	90.52	(†)
15.....	85.52	5.92	91.42	100
20.....	91.08	.02	91.10	(†)
23.....	84.27	5.93	90.20	100
24.....	93.23	1.03	94.26	(*)
30.....	86.55	4.90	91.45	80
32.....	86.33	5.11	91.44	100

* Oleo oil.

† Oleomargarine.

The writer is unable to explain these low percentages; whether the mistake is in the manner of proceeding or in the method. A series of experiments with No. 3, a sample of pure creamery butter, clearly pointed out that evaporation of *all* alcohol before dissolving the soap is essential. The following were the results:

No.	Alcohol not evaporated.			Alcohol evaporated.		
	Insoluble.	Soluble.	Total.	Insoluble.	Soluble.	Total.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....	84.36	4.95	89.31	85.95	5.41	91.36
2.....	83.42	4.79	88.20	86.07	5.06	91.01
3.....	85.02	4.93	89.95		5.35	91.42
Average.....	84.20	4.89	89.15	86.01	5.27	91.22

"Koettstorfer's method, carried on as directed by the author (see Blyth, Foods, p. 296); results given are average figures of two or more determinations.

"Water, determined by drying in copper oven for one hour at 100° C. in a current of carbonic acid, the details of the process will be discussed in a future publication.

"Ash, determined by Dr. S. M. Babcock's method (see fifth annual report of New York Agricultural Experiment Station, p. 335), about 3 grams of butter taken for determination. Duplicate determinations made; duplicates agreed within .04 of 1 per cent., the following being the results: 2.14 and 2.18; 2.20 and 2.21; and 4.94 and 4.95; .85 and .88.

"Caseine (curd), determined by Kjeldahl's process, the fat of the butter being previously dissolved out by ether. About 2 grams of butter taken for the determination."

Analyst C.—Volatile fatty acids, expressed in cubic centimeters of $\frac{1}{10}$ normal NaOH solution, determined by Reichert's method.

"Specific gravity of filtered fat by Westphal's balance at 100°C., as described in report Connecticut Agricultural Experiment Station, 1886.

"Water determined by heating 2 grams at 100° and then at 110°C., in flat platinum dish two to three hours."

Analyst D.—The moisture, curd ash, and total fat by direct weighing were estimated as follows:

"Into a small beaker of known weight was placed a short-necked funnel fitted with a plaited double filter. A second weighing was made. The sample was now thoroughly mixed and enough added to the funnel to weigh exactly 10 grams. The beaker funnel and contents were placed in an air bath at 105° for about one and one-half hours. By this manipulation the curd and salt are separated from the fat, and the water is driven off, all in one operation. I found that a single filter would not always retain the curd and salt completely. The filter was exhausted with ether into a second weighed beaker, the ether evaporated, and the weight of this fatty residue added to the weight of the first filtrate. The filter was ignited for ash. The specific gravity was taken in ordinary specific gravity bottles holding about 25 grams and fitted with perforated ground-glass stoppers. The body of the bottle was immersed in a water bath and the temperature gradually raised to 40°. This rise of temperature proceeded slowly. For Koettstorfer's equivalent, Allen was followed."

Analyst E.—Does not report methods employed. Samples 1 and 2 are reported to be artificially colored. No. 3 is reported to be adulterated with 15 per cent. foreign fat; allowing 88 per cent. to be the average of insoluble acids.

Analyst F.—The curd was determined by first exhausting with ether, drying and igniting the residue.

"Salt by the volumetric method with KCrO₄ as indicator, as directed in Bulletin No. 13, part 1, pages 73 and 74."

Analyst G.—The determination of volatile acid, soluble and insoluble acids, was made according to the methods described in Bulletin No. 13, part 1, pages 57, 66, and 67.

Analyst H.—The determinations were made by the methods described in Bulletin No. 13, part 1, viz: Specific gravity, pages 40 and 41; volatile acids, pages 57 and 58; melting point, page 45 *et seq.*; water, by drying on sand for two hours at 105°; salt, pages 73 to 74; curd, page 74; iodine absorption, pages 63 to 64.

PHYSICAL CHARACTERISTICS.

The examination of the butter samples with the microscope was only made by two of the analysts, viz: A and H. Their results are entirely concordant, save that in No. 3. A reports a slight appearance of prismatic colors in the field of vision with the selenite plate which was not observed by H.

This agreement lends emphasis to the opinion expressed in Bulletin No. 13, part 1, page 39. The boiling of the suspected fats and their subsequent examination, after crystallization, with polarized light, appear to be of no value whatever in qualitative separation of butters.

SPECIFIC GRAVITY.

The agreement in specific gravity determinations is reasonably encouraging.

With the exception of the results of C, which were made by a separate method, the following points are noticed. A D and H were determined in picnometers at 40°.

Sample.	Results.		
	A.	D.	H.
No. 1	.9060	.9063	.9060
No. 2	.9040	.9056	.9046
No. 3	.9087	.9086	.9091
No. 4	.9114	.9105	.9109

No other methods were employed with more than one sample. At least in the absence of any report irrespective of E the above remark is true.

The results at 40°C. in picnometer are so concordant that it will not be difficult to secure the adoption of this method by the Association.

MELTING POINT.

Reports A. and H. follow the method of the author. (Bul. No. 13, part 1, pp. 45 *et seq.*) Following are the data:

Sample.	Melting point.	
	A.	H.
	° C.	° C.
No. 1.....	32.0	31.8
No. 2.....	39.5	40.1
No. 3.....	35.0	34.5
No. 4.....	34.4	33.0

No other method was used by more than one analyst, and hence a like comparison cannot be made.

The results of the other methods differ so widely from each other and from the nearly agreeing results of the author's process as to show the small value which they possess.

The agreement in the comparison given is so close as to excite a hope that the method, when strictly followed in all its details, will afford results which are valuable. This value is especially noticeable in sample No. 2, where the melting point alone indicates a "neutral lard."

CHEMICAL CHARACTERS.

Volatile acids.—The value of the distillation method for sorting butter is again manifested in the results under consideration.

The process having been essentially the same with all the analysts, the whole number of results may be directly compared.

The most noticeable feature of this comparison are the peculiar results obtained by F, results which could only have arisen through some error of manipulation, probably due to some of the sulphuric acid being carried over during the process of distillation.

These errors of F, however, are confined to samples Nos. 1 and 2 and disappear in 3 and 4. This circumstance renders their occurrence the more inexplicable.

The results for samples 3 and 4 are decidedly satisfactory. When it is considered that a systematic chemical examination of butter is almost a new branch of chemical work in this country, the agreement of the results must be considered a cause of congratulation.

The two samples of butter, viz., 3 and 4, happily represent very nearly the mean and maximum of decinormal alkali consumed by the distillate obtained by Reichert's method. It is easy to see, however, that with a butter like No. 4, requiring nearly 16 cc. N. $\frac{1}{10}$ alkali for the distillate from 25 grams, a considerable adulteration could be produced without exciting suspicion, if examined by Reichert's method alone.

Thus 1 gram of No. 1 would give .1 cc. and 4 grams No. 4 12.8 cc., in all 12.9 cc., which would be declared pure butter if examined by distillation alone. Such a mixture, however, viewed by polarized light through selenite would show prismatic colors and crystals of the adulterant.

Its specific gravity would also be 1 gram No. 1 = .9050; 4 grams No. 4 = 3.6436; 5 grams = 4.5486; specific gravity of mixture = .9097.

This number is not convincingly low, but, taken with the variegated field of the microscope, would be good circumstantial evidence. Continuing the comparison further in respect of the melting-point, it is seen that the mixture of 1 part of No. 1 with 4 parts of No. 4 would not affect the melting-point in a noticeable manner. But the case is quite different if mixed with No. 2.

Here we have the following data: 1 part No. 2, 40°; 4 parts No. 4, 132°; 5 parts 172°, and the melting-point of the mixture would be 34.4°. This is not above the maximum for a pure butter, but the average for pure fresh butter is about 33.8°. Thus another circumstantial proof would be brought into court.

Nevertheless, the distillation test is the best single chemical operation to establish the purity of a butter.

Insoluble acids.—The determination of insoluble acids appears to have been made essentially by the same process, and the results show that it requires special training on the part of analysts to secure uniform results.

I may say, not having made them myself, that the results reported by analyst G have behind them more than two years of quite constant practice of the method, and I am inclined, without disparaging the data of the other analysts, to take these as a basis of comparison.

The results for the several samples are as follows:

No.	Per cent.
1	94.61
2	94.10
3	87.91
4	87.43

I will say of the above results, that if they are not correct, then neither long practice nor a high degree of analytical skill can secure accuracy.

You will only have to glance at the tabulated results to see that in the case of these acids it is necessary to carefully watch the minute details of the manipulation. These details are carefully set forth in the scheme of analysis submitted herewith for the consideration of the Association.

Saponification equivalent.—The general agreement is good and shows that with careful manipulation the results are strictly comparable. The method recommends itself by the ease and rapidity of manipulation, as will be seen in the appended scheme of analysis.

Water.—The variations in the per cent. of water obtained are somewhat surprising and illustrate again the necessity of the adoption of some uniform method by the Association. The water, however, is not uniformly distributed in the butter, and hence variations from this cause must be expected.

Salt.—The agreement here is also encouraging. The salt was estimated as ash by Babcock's method. (5 Ann. Report N. Y. Ag. Exp. Sta., p. 335) by A and B.

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
A.....	2.12	2.11	5.11	1.00
B.....	2.18	2.21	4.95	.87

It would be unreasonable to demand a better agreement than the above. The method is shown to be most excellent.

By analysts F and H the salt was determined volumetrically by the author's method.

Results.

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
F.....	1.82	1.99	4.53	.86
H.....	1.99	2.11	4.56	.79

In these two sets of analyses we have also a most satisfactory agreement. The per cents are slightly less than in the first set, for this method determines nothing but NaCl. It would be well to combine it with Babcock's method and thus determine both ash and NaCl. If the ash should show any notable increase over the salt, it would indicate the addition of borax, sodium carbonate, or some other mineral substance to the butter.

Curd.—A and B determined curd by conversion into ammonia by Babcock's method. Following are the results obtained :

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
A.....	.47	.27	.65	.65
B.....	1.11	.93	1.44	1.34

B's results are uniformly higher than A's. The method, therefore, needs to be followed in uniform detail.

In a general review of the analytical data may be seen the fact that, while there is a near agreement in many instances, yet much is to be done before the work of the various members of our Association can be considered strictly comparable.

In view of securing greater uniformity in this respect, I beg leave to submit for the consideration of the members of the Association, the following outlines of methods for the coming year:

[The recommendations of Dr. Wiley, on behalf of the committee, were adopted with a few changes, which are mentioned in the following discussion and appear among the official methods in Appendix A.]

Dr. Wiley then continued his report in relation to milk:

It is not possible to prepare and send samples of milk for comparative analysis as was done with butter samples. Therefore, I am not able to present to the association data which illustrate the merits or demerits of the different processes of analysis.

It seems best, therefore, that I should submit for your consideration an outline of analytical methods which experience has shown to be reliable. With such modifications as may be made in this "committee of the whole," I feel sure that by following such a uniform method uniform results will be obtained.

Within a short time the methods of milk analysis have undergone a radical change and in scarcely any other branch of agricultural chemical analysis would schemes of examination prepared even two years ago, and at the present time show such marked differences.

The old methods of gravimetric determinations of fat in milk are almost entirely obsolete, while, of the volumetric methods, only the modified form of Soxhlet's process and the determination by the lactocrite have met with common acceptance.

In this connection also I must not fail to mention the method of Morse, in which anhydrous copper-sulphate is used for drying the milk, and the fat, after extracting with petroleum, is estimated by saponification. In preparing the following scheme for the examination of milk I have thought it best not to recommend Soxhlet's method for two reasons, one of which is that I have shown that its results, as computed by the table, are slightly too low, and especially because all the members of the association may not be provided with the apparatus.

H. W. WILEY, *Chairman.*

The recommendations as amended were adopted and appear among the official methods on the Appendix.

On the conclusion of the report the convention adjourned to meet at 2 p. m.

TUESDAY AFTERNOON.

The convention was called to order at 2 p. m., and, the discussion of the report of the committee on dairy products being in order, agreed by unanimous consent to listen instead to the report of methods from the committee on cattle foods as agreed upon after recommitment.

The committee reported for use during the ensuing year the methods given in the Appendix, and their report was adopted.

On motion of Dr. McMURTREE it was voted: That the committee on cattle foods be directed to collect such information on the subject of the determination of water as can be obtained, and recommend some method at the next meeting for adoption.

The convention then entered on the discussion of the report of the committee on dairy products, and the reading of papers being in order the following were presented:

**AVERAGES OF ANALYSES OF AMERICAN BUTTERS, BY EDGAR RICHARDS, CHEMIST
TO THE UNITED STATES BUREAU OF INTERNAL REVENUE.**

In connection with the report of the committee on dairy products the following tables giving the analyses of samples of genuine butter and of some butter substitutes may prove of interest.

The methods pursued in the analyses were those recommended by the chairman of the committee, in his report just read, and which have been followed by the division of chemistry of the Department of Agriculture since 1883.

A table showing the analysis of various fats, compiled from Allen's Commercial Organic Analysis, 2d edit., vol. 2, is presented for comparison.

TABLE I.—Analyses of genuine butter, American.

[Analysts Crampton and Richards, Department of Agriculture, 1883-'86.]

	Water.	Casein.	Salt.	Specific gravity at 40° C.	Soluble acids.	Insoluble acids.	Saponification equivalent.	Vol. N NaOH for 2.5 grams.
Fifty-two samples:	<i>Per cent</i>	<i>Per cent</i>	<i>Pr. ct.</i>		<i>Per cent</i>	<i>Per cent</i>		
Average.....	10.49	.699	8.27	.91128	4.77	87.79	247.6	18.50
Highest.....	17.44	1.230	7.10	.91250	6.79	89.65	268.5	15.60
Lowest.....	4.44	.268	1.08	.90995	3.00	86.43	236.5	12.30
Fresh butter, 24 samples:								
Average.....	11.42	.622	2.48	.91105	4.81	87.99	248.6	18.90
Highest.....	17.44	.988	6.15	.91235	6.79	89.26	268.5	15.30
Lowest.....	8.14	.268	1.08	.91030	3.00	86.43	239.8	12.90
Tub butter, 26 samples:								
Average.....	9.57	.602	4.08	.91151	4.73	87.78	246.7	13.42
Highest.....	13.67	1.230	7.10	.91250	5.94	89.55	254.2	15.60
Lowest.....	4.44	.268	1.81	.90995	3.47	86.60	236.5	12.30
Individual cows:								
Jersey cow, value 2d.....	9.98	.660	1.64	.91102	6.79	86.72	239.8	.....
Do.....	12.54	.622	1.64	.91089	4.52	88.02	247.1	.....
Jersey cow, Washington, D. C.....	11.89	.268	2.61	.91073	4.69	87.71	244.9	14.10
Celebrated dairies:								
Hampton, Baltimore, Md.....	14.06	.507	2.78	.91149	4.97	88.46	247.3	.....
Darlington, Darlington, Pa.....	11.67	.455	1.42	.91049	4.21	89.26	252.8	.....
Do.....	11.46	.831	1.48	.91165	5.49	87.50	250.1	13.10

TABLE II.—Analyses of butter substitutes.

[Analysts Crampton and Richards, Department of Agriculture, 1883-'86.]

	Water.	Casein.	Salt.	Specific gravity at 40° C.	Soluble acids.	Insoluble acids.	Saponification equivalent.	Vol. N NaOH for 2.5 grams.
Suspected butter, 13 samples:	<i>Per. ct.</i>	<i>Per cent.</i>	<i>Pr. ct.</i>		<i>Per cent.</i>	<i>Per cent.</i>		
Average.....	10.55	.624	2.96	.90948	3.94	88.66	253.1	12.30
Highest.....	12.92	.963	5.40	.90987	4.84	89.89	260.1	13.10
Lowest.....	7.45	.297	1.50	.90882	3.02	87.90	249.4	11.60
Oleomargarine.								
Do.....	9.32	.087	4.03	.90380	0.00	94.80	283.9	.....
Do.....	5.67	.172	3.31	.90488	0.20	93.42	282.5	.....
Do.....	10.28	.905	2.81	.90510	0.56	98.65	280.7	.....
Do.....	9.34	.250	3.64	.90490	0.12	93.69	274.0	0.70
Average.....	8.50	.829	3.45	.90462	0.22	98.87	280.3	.....
Butterine.								
Do.....	11.09	.806	2.39	.90569	1.18	92.90	274.6	4.80
Do.....	14.45	.875	2.42	.90561	0.09	93.72	281.1	1.90
Lard, leaf.								
Do.....	0.00	.000	0.00	.90480	0.00	95.40	284.7	.....
Do.....	0.00	.088	0.00	.90538	0.41	92.58	294.3	0.20
Lard, neutral.								
Do.....	7.42	.....	0.40	.90369	0.20	90.00	270.5	0.30
Beef, suet.								
Do.....	0.00	.....	0.00	.89697	0.00	94.80	290.0	.....
Do.....	0.00	.....	0.00	.90158	0.22	92.59	296.6	0.10
Oleo fat.								
Do.....	14.23	.....	0.97	.90287	0.10	93.35	296.2	0.20

TABLE III.—Average analysis of various fats.

[By A. H. Allen.]

	Water at 15.5° C.=1.				Water at 37° C.=1.		KOH for saponification.
	Specific gravity.	At—	Specific gravity.	At—	Specific gravity.	At—	
		°		°		°	<i>Per cent.</i>
Butter fat.....	.9041 .926 to .929	40 15.5	.8677 .867 to .870	99 99	.9094 to .9140	37.8	22.15 to 23.24
Butterine.....	.8982 .915	40 15.5	.8592 .8585 to .8630	98 98	.9014 to .9060	37.8	19.35 to 19.65
Lard.....	.8985	40	.8608	98	.9038 to .9050	37.8	19.20 to 19.65
Lard oil.....	.915 to .919	15.5					19.10 to 19.60
Tallow.....	.8950	50	.8626	98	.9028 to .9037	37.8	19.32 to 19.80
Tallow oil.....	.916	15.5					
Drippings.....					.904 to .907	37.8	19.65 to 19.70
Cotton-seed oil.....	.925 .922 to .930	15.5 15 to 15.5	.8725	98			19.10 to 19.66
Cotton-seed stearine.....			.866	98	.911 to .912	37.8	
Olive oil.....	.914 to .917	15 to 15.5					18.93 to 19.60

	Koettstorfer's equivalent	Vol. $\frac{N}{10}$ KOH per 2.5 grams.	Acids insoluble.	Acids soluble.	Solidifying point.
			<i>Per cent.</i>	<i>Per cent.</i>	°
Butter fat.....	241 to 258	12.5 to 15.2	86.5 to 89.0	4.5 to 7.0	20 to 30
Butterine.....	285 to 290	0.2 to 1.6			18 to 38
Lard.....	286 to 292				27 to 44
Lard oil.....	285 to 293				-4 to +10
Tallow.....	283 to 289				33 to 48
Tallow oil.....					0 to +6
Drippings.....	284 to 285				
Cotton-seed oil.....	285 to 293	0.8			1 to 4
Cotton-seed stearine.....	285 to 294				
Olive oil.....	284 to 296				+4 to -6

TABLE III.—Average analysis of various fats—Continued.

	Melting-point.	Br. absorption, Mills.	Iodine absorption.		
			$\frac{1}{100}$ Br. absorption.	Hübl.	Other observers.
Butter fat.....	° 29 to 35	Per cent. 24.5 to 27.9	Per cent. 38.9 to 44.4	Per cent. 26.0 to 35.1	Per cent. 19.5 to 38.0
Butterine.....	34 to 40	36.3 to 39.7	57.7 to 63.1	55.3	50.0
Lard.....	28 to 45	37.8	59.3	59.0	61.9
Lard oil.....					
Tallow.....	36 to 49			40.0	
Tallow oil.....					
Drippings.....					
Cotton-seed oil.....		50.0	79.5	105 to 108	106 to 109
Cotton-seed stearine.....	32				
Olive oil.....		54.0 to 60.6	85.9 to 96.4	81.6 to 84.5	83.0

VARIATIONS IN THE COMPOSITION OF BUTTER, BY DR. S. M. BABCOCK, OF THE NEW YORK AGRICULTURAL EXPERIMENT STATION.

I had the good fortune to obtain from the dairy show held in New York in May, 1887, twenty-six samples of butter for analysis. Fourteen of these were from the exhibition butters, and included several of the prize packages; the others were butters made at the fair from the milk of single cows entered for the sweepstakes butter prize. Nearly all were from thoroughbred stock, the Jerseys and Holsteins predominating.

These samples were tested by several of the methods generally employed by chemists for the detection of adulterations, viz: The volatile fatty acids used by Reichert's test, the saturation equivalent by Koettstorfer's method, the iodine number, as proposed by Hübl, the melting-points, and the viscosity of aqueous solutions of the potash soaps. Reichert's, Hübl's, and Koettstorfer's tests were made in the usual way. The melting-points were determined by Wiley's method. The details of the viscosity test are as follows: To 15 grams of the filtered fat, in a beaker of about 500 cc. capacity, are added 10 cc. of a strong solution of potassium hydrate (1 cc.=0.5 grams KOH) and 10 cc. of alcohol (95 per cent). The beaker is placed upon a water bath and heated with occasional shaking till the fat is saponified and the alcohol driven off. About 350 cc. of water are then added and heated till the soap is completely dissolved, after which 10 cc. more of the potassium hydrate solution are added. When the precipitate which forms is dissolved, the solution is transferred to a 500 cc. flask and made up to the mark with water. After it has cooled to 20° C. the volume is adjusted to 500 cc., and the viscosity determined by any reliable viscometer. The apparatus which I have used is described in the report of the New York Agricultural Experiment Station for 1886, also in the Journal of Analytical Chemistry, April, 1887. This apparatus has worked satisfactorily, the slightest difference in viscosity being shown. This sensitiveness is very desirable for determining variations in the com-

position of butter fats, but for the detection of adulteration is not necessary. Nearly all cases of commercial adulteration will be shown by simple inspection, as their soap solutions are very viscous. In most cases where doubt exists, an observation of the time required for a given volume of the solution to run from a large pipette with small jet will be sufficient to show whether the sample is butter or a substitute. The viscosities given in my work are all expressed by the number of grams of cane sugar which, dissolved in water and made up to one liter, make a solution of the same viscosity as the liquid under examination.

The results of all of these tests are presented in the accompanying table, the butter being arranged according to breed of cow so far as this is known.

Kind of butter.	Reichert's test n-10 NaOH cc.	Hübl's test iodine number.	Koettstorfer's test ngr. KOH for 1 gm. of fat.	Melting- points °C.	Viscosity of soap solutions.
Jersey butters:					
No. 1.....	16.1	34.5	227.5	32.7	103
No. 2.....	14.1	30.5	227.1	33.3	54
No. 3.....	13.2	35.3	229.8	33.7	71
No. 4*.....	14.1	32.6	231.1	33.8	81
No. 5*.....	11.5	35.6	223.1	33.2	97
No. 6*.....	13.2	25.9	232.5	35.4	50
No. 7*.....	14.4	23.8	232.2	34.0	65
Average.....	13.8	31.2	229.0	34.0	74
Holstein butters:					
No. 8.....	16.1	41.4	224.0	34.6	297
No. 9.....	12.5	41.0	220.5	34.9	256
No. 10*.....	14.4	44.7	224.3	32.1	461
No. 11*.....	14.1	40.1	226.8	32.4	179
No. 12*.....	13.9	42.2	227.6	30.5	187
No. 13*.....	12.1	34.6	222.7	36.9	166
No. 14*.....	16.0	36.1	229.4	32.4	112
Average.....	14.1	40.0	225.0	33.4	237
Guernsey butter:					
No. 15.....	15.6	36.9	227.2	33.5	153
No. 16*.....	14.3	33.9	232.0	33.0	68
Ayrshire butter:					
No. 17*.....	9	37.8	233.3	33.5	66
Breed unknown:					
No. 18.....	13.3	35.4	227.8	33.5	71
No. 19.....	12.9	41.2	222.3	33.0	208
No. 20.....	13.9	33.3	227.2	34.6	65
No. 21.....	14.1	33.8	237.8	33.5	65
No. 22.....	14.2	32.8	228.0	35.0	100
No. 23.....	13.4	33.3	228.5	34.4	88
No. 24.....	13.5	30.2	224.8	33.2	103
No. 25.....	14.1	31.9	228.0	33.0	62
No. 26.....	13.9	37.8	232.3	33.5	66
Average.....	13.9	35.6	228.2	33.8	93
Average for all.....	13.95	35.6	227.5	33.7	127

* Butter from the milk of a single cow.

An inspection of this table shows that the variations in all of the tests are greater than has been generally supposed. Especially is this true with those butters from the milk of a single cow. These variations are so marked that the application of any single test might fail to detect even 30 per cent. of adulteration. It is, however, unlikely that a pure butter will be found deficient in all respects, so that, in doubtful cases, the application of as many tests as possible is advisable.

The report of the committee was then taken up for discussion by sections.

PHYSICAL METHODS—MICROSCOPIC TESTS.

Dr. BABCOCK approved of the use of the microscope as a negative test—that is to say, with the selenite and polarized light a variegated

field would indicate something other than pure butter, although some butter which had been adulterated might show a homogeneous field.

Dr. JENKINS asked how "baled" butter would act, and was informed that it would give results like pure butter.

The section was then adopted.

SPECIFIC GRAVITY.

Dr. WILEY said 40° C. was selected instead of 37° C., as some substances, such as neutral lard, do not melt completely at the lower point.

Dr. JENKINS spoke of the use of the Westphal balance, and said: We have had considerable work to do in the examination of butter for our State dairy commissioner, and have found Westphal's balance extremely convenient for the purpose of taking specific gravity of the melted fat. The method is fully described and results given in our last annual report. The chief advantages of the method are rapidity of execution, accuracy, and the comparatively small volume of fat required.

Dr. WILEY replied that a large number may be done at one time in picnometers.

Several members then spoke of the possibility of calculating results obtained at 100° C. to 40° C. for comparison. A table of co-efficients of expansion was said to be given in Allen's Commercial Analysis.

The section was not modified.

MELTING-POINT.

The method of Wiley, as described by him, met universal approval and was not modified.

CHEMICAL METHODS—REICHERT'S PROCESS.

Dr. WILEY said that sulphuric could be used as well as phosphoric acid, if care was exercised, and was confirmed by Dr. Crampton. The following results were cited:

	P ₂ O ₅ .	H ₂ SO ₄ .
Volatile acids.....	15.39 15.90	15.75 And less.

Professor CALDWELL thought as many transfers as were described were dangerous and would prefer to saponify in flask with a long tube as condenser, completing all the operation in one vessel.

Dr. BABCOCK stated that he had found some difficulty in removing the alcohol, but by the use of strongest aqueous potash and adding only 3 or 4 cc. of alcohol, which is readily removed, he avoided trouble. The saponification is rapid.

Dr. JENKINS said he used the same method, since the alcoholic potash seemed to decompose in time and the results obtained were too high.

Dr. CALDWELL asks if a tube to act as condenser is necessary in this way of working.

Dr. JENKINS said he used one.

Dr. BABCOCK did not, since saponification was so rapid and complete before the boiling-point is reached.

It was then moved and adopted to substitute Dr. Babcock's method.

INSOLUBLE ACID.

The method described was adopted without modification.

SATURATION EQUIVALENT.

Dr. BABCOCK pointed out the necessity of having the alcoholic potash free from carbonate.

Dr. WILEY confirmed the statement, and said that saponification could only be completed with great difficulty in presence of carbonate.

The section was then adopted.

WATER.

Dr. WILEY said he found nothing necessary to assist in driving off water.

Dr. JENKINS found sand an assistance.

The section was adopted.

SALT, MINERAL MATTER, CURD.

These sections were adopted without change.

Dr. WILEY then suggested the addition of the method of *iodine absorption* as being simple and valuable.

A motion to do so was made and carried.

Dr. McMURTRIE asked for the best method of separating the water and curd from the fat.

Dr. WILEY described his method as in use in the Department of Agriculture, as follows: The butter is melted and allowed to stand until the water and curd have settled. The supernatant liquid fat is then poured off through a dry filter placed in a hot water jacketed funnel.

Dr. JENKINS said he found, at times, when but little water is present, that the addition of a spoonful of salt was advantageous.

It was moved to introduce this in the official method, which was carried.

The report on butter was then recommitted, and the Convention adjourned to Wednesday morning, the 17th, at 10 o'clock.

WEDNESDAY MORNING.

The report on method of milk analysis being in order for discussion it was taken up by sections.

On the determination of water, Dr. JENKINS spoke as follows:

"We have found no method of determining water and fat in milk superior in accuracy or speed of execution to the sand method—that is, evaporating the milk with a known weight of dry sand to determine water, and extracting the pulverized residue with absolute ether in Johnson's, sometimes called Tollen's, extractor to determine fat. It has been abundantly proved that this method determines water with absolute accuracy. It has been recently objected by English analysts that the determination of fat by this method gives lower results than by Adams's method.

"Our own experiments have shown almost perfect agreement with Adams's method when the paper coils used in the Adams process were perfectly freed from wax or resin previous to use, an operation requiring time and care. If not previously extracted, of course the results by Adams's method will be higher."

Professor CALDWELL moved to substitute for the determination of water a method which he found desirable. One to two cubic centimeters of milk are to be evaporated on a water-bath in a watch glass, a few centimeters in diameter, for thirty minutes, and then dried at 100° C. in an oven for one hour.

Mr. FARRINGTON stated that he preferred 4 cc. and four hours, to which Professor Caldwell replied that the shorter exposure by his way of working was better, and that he used a water oven for drying.

Professor MYERS, in speaking of Professor Caldwell's process, said:

"I think that it is highly desirable that the method adopted should contemplate also the determination of one or more of the other ingredients of the milk, such as the total solids and fats and ash, or the total solids and the albuminoids from the same quantity of milk used for the determination of the moisture. Should we adopt the amendment proposed by Professor Caldwell we would be forced to weigh an additional quantity for the determination of the solids and fats or solids and albuminoids. We should constantly keep before us the question of economy of time, as that is often of importance to the State analysts."

Dr. WILEY called attention to indefinite boiling-points due to variations in altitude and indefinite temperature of water-drying ovens.

Professor SCOVELL suggested in consequence a definite temperature of 98° C.

After some further discussion the motion was carried.

The use of asbestos as a combined means of estimating moisture and fat as practiced in Canada was explained by Dr. MACFARLANE, who was

requested by the Convention to **write a description** for use as an alternate during the ensuing year.

The description is given among the official methods, **Appendix A, p76.**

ALBUMINOIDS.

Dr. JENKINS referred to the determination of albuminoids by the Kjeldahl method, and said :

" Mr. Farrington has found trouble in digesting, by Kjeldahl's method, milk residues with the pulverized glass dishes referred to in the report, because of dangerous "bumping" in the liquid. We much prefer to weigh ~~from~~ 2 to 5 grams of milk directly into the digestion flask and proceed as ~~with~~ a solid substance. This method gives with us results which agree with ~~those~~ of the soda-lime method, and it has been thoroughly tested with ~~satisfactory~~ results in Germany, both with milk and with urine, where the per cent. of water runs up to 96."

A motion to introduce this ~~method~~ among those which are to be official was then carried.

FAT.

The question being raised as to the use of Adams's method for the determination of water as well as fat, the opinion ~~seemed~~ general that the results were not reliable.

Dr. WILEY described the Adams method as in use at the Department of Agriculture, and showed specimens of the paper used by Professor Adams, which he had recently received.

Several members stated that they had had difficulty in meeting with success, as the paper to be had in this country was either too fuzzy or contained considerable extractive matter not easily removed.

Dr. McMURTRIE said that he had found in the paper used by him a waxy resinous substance, with difficulty soluble in ether but freely in 90 per cent. alcohol, but that Canadian asbestos had proved an excellent absorbent, and as it could be ignited did away with all danger of having foreign material soluble in ether present.

Professor SCOVELL called attention to his use of a tin-foil dish instead of the glass Schälchen for use in determining water and fat. The residue can be equally well extracted.

On motion this method was made an alternate with the Adams method.

Dr. WILEY moved that the Morse and Pigot method with anhydrous CuSO_4 be made an alternate, and this was agreed to.

Considerable discussion then ensued on the Macfarlane asbestos method, and Professor MACFARLANE explained that he dries the milk in current of hydrogen to within .1 per cent. and gets slightly higher results than with Adams' method.

On motion of Dr. WILEY the use of the lactocrite was also approved for those who have them.

It was then agreed that the ~~alternates~~ should be carefully compared and the results reported to the next meeting.

SUGAR.

Dr. FREAK desired some other method than the ~~polaris~~copiscopic, as some operators have no instrument, and after some discussion it was agreed that the method of extraction with alcohol and of determination with Fehling solution should both be inserted.

Professor SCOVELL found difficulty with the end reaction with Fehling.

Dr. MCMUETRIE said: The end reaction may be determined accurately by ferrocyanide and acetic acid. Saturate filter paper with ferrocyanide and acetic acid; spread upon a plate. When the standard solution has been added and while boiling take a drop upon a glass rod, and placing upon the saturated paper a clean piece of filter paper, press the rod with drop upon it. If a spot appears upon the saturated paper continue the titration until no spot appears.

ASH.

Dr. MCMUETRIE moved that a small quantity, 3 cc., of nitric acid be added to the milk before incineration, which was passed, and it was moved and seconded that the method proposed by Dr. Wiley be adopted as a whole.

Professor MYERS then called for the reading of the report, which was said at the time to be impossible. He remarked:

I called for a reading of the report as amended.

[*Scattering remarks from the members.*] Mr. MYERS. Mr. President, it is not in a factious spirit that I call for the reading of this report so that the members of the Association may vote upon it intelligently. I object to passing upon such important matters in undue haste. Ordinary business care should be taken.

Professors CALDWELL, CHAZAL, and others thought it not necessary to delay action, as the committee would perfect the report.

Professor MYERS. Mr. President, I do not desire to appear in this connection as expressing lack of confidence in the committee. On the contrary, I have the highest respect for, and confidence in, every member of the committee, but the point that I desire to insist upon is this, viz: We meet here as official chemists or as chemists whose work and whose methods must exercise a very important influence upon the commercial interests of this country. There is perhaps no other scientific organization in this country that has so much dependent upon the accuracy of its methods and the efficiency of their execution. The courts, the public, and the manufacturers are all more or less directly affected by our deliberations, and we owe it to ourselves as well as to the honor of the Association to which we belong that we should not act with unseemly haste. Now, we are asked to vote upon the adoption of a method of analysis about which even the secretary of the Asso-

ciation, the chairman of the Association, and the chairman of the committee disagree as to the changes made in the report by the Committee of the Whole. It is a bad precedent for us to adopt; it is calculated to bring discredit upon us personally and upon our organization. It does injustice to science and to the great interests involved. I therefore must respectfully insist upon due deliberation and proper form of report before the members of this Association be expected to vote upon the report of this or any other committee.

The motion was then withdrawn, the report recommitted, Professor Myers being placed on the committee to fill the vacancy caused by the absence of Professor Armsby.

Mr. CHAZAL then asked unanimous consent of the convention to listen to a communication from Mr. A. De Ghequier, representing the National Fertilizer Association, which was given.

Mr. DE GHEQUIER spoke as follows :

MR. PRESIDENT AND GENTLEMEN OF THE OFFICIAL AGRICULTURAL CHEMISTS' ASSOCIATION : On behalf of the Committee on Analysis of our Association I have the honor to submit to you for favorable consideration, and such action as you may feel justified under the circumstances to take, several requests, all of which, it is believed, fall entirely within the scope of your Association. The circular issued by this Association on July 28 acquaints you with the results of an investigation made for the purpose of testing the accuracy of the present method of analysis. It will suffice for me to state that the same goods, represented as sample 9982, received at first less than 8 per cent. soluble, and less than 13 per cent. available, phosphoric acid, and this analysis was published as correctly representing the goods in question. I do not know that I can improve, as regards what the Association is anxious to obtain from you, upon the expressions made by the chairman of our Committee on Analysis. In his correspondence with me on the subject in a letter written May 7 he says : " I think we should strive to get the chemists to agree to certain conditions of sampling and analyzing, in order to give the manufacturers some protection, whereas at present they have little or none. The following points, it seems to me, are important in this direction : The sampling should be done from a representative number of packages in each lot, and not, as is the case in many instances, from a single bag of 100 or 200 pounds. The sample should be drawn from different portions of the sack, that is to say, not be a sample from the top; and, then, in drawing the final sample from the mixture of all the samples, great care should be used to get a representative one. Duplicates should in all cases be held by the chemists subject to the order of the manufacturer."

Another important point in sampling is this : Samples should always be drawn without any knowledge on the part of the manufacturers that such sampling is done; that is, at points where there will be no chance of the manufacturers having any knowledge as to the sampling being

done. In other words, every precaution should be taken to get representative samples of each manufacturer's goods as found on sale in the open market. The analysis question is still more important. Uniform methods for determining all elements should be agreed upon and strictly adhered to, and all analyses should be made in duplicate, and, where possible, by different methods, as a check. The analyses should in all instances be reported to the manufacturers whose goods are sampled before they are published, in order to give the manufacturer a chance for protest. The protest need not necessarily affect the station's decision about the publication of the analysis, unless sufficient grounds are furnished for the objection, but a chance for protest should certainly be given to the manufacturer. Where such a protest is made the director ought certainly be willing to go over the results in person, as oftentimes, I believe, errors are made by careless or incompetent assistants. Where nitrogen is claimed to be present in the form of nitrate of soda each chemist should certainly not only be willing but ought to be bound to analyze by the absolute method, or by such a method, at any rate, as will determine nitrogen in the form of nitrates. We are constantly having trouble from this source, the chemists not giving us sufficient nitrogen. I do not suppose that the time has come when chemists will consent to give up valuations, but it should come soon, as there is certainly no justice whatsoever in placing valuations upon each manufacturer's goods when the chemists cannot, by any possibility, tell what the real agricultural or intrinsic value of the goods in question is. Determining, as they do, simply the chemical elements of plant-food, the chemists cannot on this alone compute a value on any fertilizer that is fair to the manufacturer, for some materials are valuable as plant-foods, and consequently high priced, while others are of very little value, and consequently of very low price. Then there is nothing ascertained as to the mechanical condition of the fertilizer, its dryness, fineness, the thoroughness with which it is mixed, &c., all points of the greatest importance to the farmer. Also there is no credit given for the proportions of the elements found in the fertilizer. A fertilizer containing a very large proportion of nitrogen and very little potash or ammonia would be given the same valuation by a chemist, if it were used for a potato or corn crop, as one containing the proper proportions of the three elements required for these crops. All these points are, I think, of great importance, and should be properly weighed by the directors of the State Experiment Stations in making up their reports of the various fertilizers inspected by them. As it would be impossible for them to correctly take into consideration in their valuations these elements, they should not give valuations, but merely the guaranteed composition of the fertilizers and their own analyses, for comparison. Another point against valuations is that they tend to keep the farmers and the public in ignorance as to the relative merits of chemical fertilizers, based upon their composition, whereas the di-

continuance of the publication of valuations would oblige the public to scrutinize the analyses closely, the percentages of the different elements found in each fertilizer, compared with the guaranteed percentages, and the relative merits of one fertilizer as compared with another, based on the relative proportions of the different elements existing in each. In other words, to discontinue publishing the valuations would tend to educate the farmers, as they would no longer, as they do at present, merely compare with each other the valuations given the various fertilizers. I think it would be well for the Association to present to the chemists a statement embodying some of these views with others that are important, and then make certain requests as deductions from these arguments, to be adopted and strictly adhered to by all the Association chemists in their inspection of commercial fertilizers.

Following is the circular of the Exchange:

THE NATIONAL FERTILIZER ASSOCIATION,
Baltimore, July 28, 1887.

Complaint having been made to the committee on analysis about very unsatisfactory, because exceedingly low results of the official analyses in the State of Ohio, the committee on analysis decided to institute a test case and selected for that purpose two kinds of acid-phosphate, one being dissolved land, the other dissolved river-rock. The co operation of the State Board of Agriculture had been secured beforehand, and the secretary of said board drew in person samples from each lot which were by him divided, sealed, and forwarded by express to the following chemists: Professor Lord, of Ohio; Professor Kedzie, of Lansing, Mich.; Professor Johnson, of New Haven, Conn.; Professor Wiley, chemist to the United States Department of Agriculture and to the National Fertilizer Association. This last sample was once more subdivided and expressed to Dr. Chas. W. Dabney, of Raleigh, N. C.; and sent to Prof. Wm. Simon, and the manufacturer of the goods.

The results are herewith submitted as follows:

	Sample No. 9982.					Sample No. 10720.				
	Soluble.	Reverted.	Insoluble.	Available.	Total.	Soluble.	Reverted.	Insoluble.	Available.	Total.
1.....	10.35	3.18	2.29	13.53	15.82	10.38	2.79	1.19	13.17	14.36
2.....	9.76	3.29	2.67	13.04	15.71	9.92	2.78	1.72	12.70	14.42
3.....	12.00	1.59	2.34	13.59	15.93	9.50	2.53	1.90	12.03	13.93
4.....	9.97	3.62	2.10	13.49	15.50	10.09	2.90	1.40	11.99	14.39
5.....	10.50	3.05	2.54	13.55	16.09	10.71	2.76	1.40	13.47	14.86
6.....	11.06	3.09	2.12	14.15	16.27	11.57	1.63	1.53	13.20	14.73
7.....	10.85	2.30	3.22	13.15	16.37	10.83	2.44	1.98	13.27	15.25

It will be seen that the two analyses marked No. 1 and No. 5 agree very closely and represent the fair average between highest and lowest results. But if the analysis No. 3, in both cases, is analyzed, it is apparent that the same chemist who found the least percentage of soluble in one sample found the highest in the other, and the 12.03 available of sample 10720 form a strong contrast to the 13.47 obtained by another chemist of the same sample. The difference calculated as commercial value shows the same article to be of too different value to be classified as identically the same article, yet on analyses differing thus widely a manufacturer's reputation rests without any redress whatsoever. Who is responsible for the injury done a manufacturer's

goods by the publication of analyses which often are proven erroneous "*post festum*?" It would seem a matter of justice to the manufacturer to accord him, in all cases where the official analyses fall below the standard claimed, an opportunity to verify its correctness. After publication of an erroneous analysis, the mischief wrought cannot be undone. The members are therefore requested to express to the secretary their views on this important matter prior to August 10, proximo, so that the committee may be enabled to lay before the next meeting of the Official Chemists' Association, which will be held in Washington, on August 16, a memorial embodying the views of the members.

It is desirable, also, that members, whose business suffered actual injury from the premature publication of incorrect official analyses, should put the association in possession of such facts, so that the necessity of a much needed reform of the present prevailing practice may be illustrated in the most forcible manner possible.

The committee are of the opinion that imperfect sampling has much to do with the unsatisfactory results which are still of too frequent occurrence. It is also believed that the inability of the chemists to make all analyses in person accounts for many serious discrepancies. At the same time the committee is of the opinion that where a manufacturer's reputation is at stake, and grave injury done to his business, an inexperienced assistant is not the proper person to attach an arbitrary value to goods on the strength of what is often an inaccurate analysis.

For the Committee on Analysis,

ROBERT S. BRADLEY, *Chairman*.
A. DE GHEQUIER, *Secretary*.

Professor LORD then made some remarks in regard to the case, and Mr. CHAZAL moved that the communication be referred to a committee of three, with the chair as *ex officio* chairman.

This motion was seconded and carried, and the chair appointed Messrs. Chazal, Gascoyne, and Lord upon the committee.

The Commissioner of Agriculture then expressed his regrets to the convention at being unable to address them at length, and his pleasure at seeing the Association in such a prosperous condition. He desired to do all that he could to assist them.

Dr. McMURTRIE then asked unanimous consent which was granted, to present a communication from the State Board of Agriculture of Illinois.

Dr. McMURTRIE stated that in his letter of instruction from the State Board of Agriculture of Illinois he was directed to urge the appointment of a committee to prepare uniform blanks for use of all interested in the inspection of commercial fertilizers, so as to insure, as far as possible, uniformity of procedure. The same board also request that the Association determine upon a definition of the term "commercial fertilizer." He also presented copies of the Illinois law and of blanks adopted according to the conditions thereof.

Professor SCOVELL moved to refer the request to a committee of three, which was seconded and carried.

The chair appointed Messrs. McMurtrie, Stubbs, and Scovell.

The Dairy Committee then read the official methods, as agreed upon, for the ensuing year, and they were accepted as a whole*

The convention then adjourned till 1.30 p. m.

* See appendix A.

WEDNESDAY AFTERNOON.

The Convention was called to order at 1.30 p. m., and in the regular order listened to the report of the Committee on Phosphoric Acid, presented by Professor Stubbs, chairman.

REPORT OF THE COMMITTEE ON PHOSPHORIC ACID.

The Committee on Phosphoric Acid respectfully submits the following :

It has been customary for previous committees to divide their reports into three parts: (1) Brief notices of new analytical methods for determining P_2O_5 proposed during the year; (2) Results of co-operative work done by the committee and members of the Association; (3) Recommendations for the next year.

I. The very full reports previously made and the almost complete absence of new literature on P_2O_5 during the past year renders our duty under the first head short and decisive. We know of no new methods worthy of recording.

II. Early in the fall of 1886 your chairman obtained samples of English and South Carolina acid phosphates. The first was selected from a cargo of 1,100 tons, imported in bulk by the Planters' Fertilizing Company of New Orleans, and was guaranteed to contain 12 per cent. soluble P_2O_5 . The other was donated by Etiwan Phosphate Company of Charleston, S. C.

A few weeks later the Navassa Phosphate Company of Wilmington, N. C., placed at our disposal a sample of their acid phosphate. These samples, so generously furnished by the manufacturers, were ground in a mill until they all passed through a sieve eighty meshes to the inch; then thoroughly mixed and smaller samples sent to twenty-one analysts with request to analyze by the methods prescribed by this Association at its last meeting. Other methods of analysis were requested. These samples were lettered *a*, *b*, and *c*.

a.—South Carolina acid phosphate.

b.—English acid phosphate.

c.—Navassa acid phosphate.

Samples were subsequently sent to several commercial chemists of Charleston and Baltimore upon application.

Unfortunately returns have been received from only six laboratories, results of which are herewith appended.

Results of phosphoric acid determinations.

Analyst.	Moisture.	Soluble.	Reduced.	Insoluble.	Total.	Available.
<i>Sample a—</i>						
A.....	18.14	5.58	4.45	2.60	12.63	10.08
B.....	12.22	5.83	4.37	2.40	12.60	10.20
C.....	.....	6.04	4.09	2.41	12.54	10.13
D.....	20.96	6.00	4.11	2.38	12.49	10.11
E.....	17.25	6.10	4.65	2.35	13.10	10.75
F.....	18.10	6.15	5.36	2.17	13.68	11.51
<i>Sample b—</i>						
A.....	15.03	9.28	2.17	.43	11.98	11.55
B.....	15.07	9.48	2.24	.43	12.15	11.72
C.....	.....	9.31	2.23	.20	11.74	11.54
D.....	16.15	9.34	2.41	.35	12.10	11.75
E.....	15.65	9.35	2.90	.85	13.10	12.25
F.....	12.86	9.26	2.81	.50	12.57	12.07
<i>Sample c—</i>						
A.....	6.42	9.63	5.17	4.73	19.53	14.80
B.....	6.31	9.53	6.06	4.11	19.70	15.59
C.....	.....	10.81	4.78	3.71	19.30	15.59
D.....	7.31	8.57	6.88	4.06	19.51	15.45
E.....	5.40	8.60	6.40	4.25	19.25	15.00
F.....	7.45	8.78	6.68	4.32	19.78	15.46

Averages.

	No. of deter- minations.	Mean.	Highest.	Lowest.
<i>Sample a—</i>				
Moisture	5	18.53	20.96	17.25
Soluble	6	5.95	6.15	5.58
Insoluble	6	2.38	2.60	2.17
Citrate, soluble	6	4.50	5.96	4.09
Total	6	12.84	13.68	12.49
Available	6	10.45	11.51	10.03
<i>Sample b—</i>				
Moisture	5	14.95	16.15	12.85
Soluble	6	9.35	9.48	9.26
Insoluble	6	.46	.85	.20
Reduced	6	2.46	2.90	2.17
Total	6	12.27	13.10	11.98
Available	6	11.81	12.25	11.54
<i>Sample c—</i>				
Moisture	5	6.58	7.45	5.40
Soluble	6	9.32	10.81	8.57
Insoluble	6	4.19	4.73	3.71
Reduced	6	5.99	6.68	4.78
Total	6	19.51	19.78	19.25
Available	6	15.31	15.59	14.80

The following may be noted in regard to the above:

(1) The determinations of moisture are, in our opinion, too varying. In *a*, *b*, and *c*, respectively, the differences between the highest and lowest results are 3.71, 3.30, and 2.05 per cent. Upon a 12 per cent. acid phosphate a difference of 3 per cent. in moisture may mean as much as .4 per cent. of phosphoric acid. An examination of results will show that the variations in moisture are not always attended by variations in P_2O_5 , a fact which shows that the variations are due rather to personal errors than to differences in samples.

(2) The determinations of total phosphoric acid are in the main satisfactory. In *a* five out of the six are within .33 per cent. of the average, the sixth one .84 per cent. of the average; four out of the six are practically the same, the average being 12.56 per cent.; the lowest, 12.49 per cent.; the highest, 12.63 per cent.

In *b* the same remarks are applicable. Two analysts, getting higher results, elevate the average, while, without their work, the average is 11.99 per cent., the highest 12.15 per cent., and the lowest 11.74 per cent.

In *c* the results are more uniform.

(3) The determinations of soluble P_2O_5 alone are very satisfactory in all but *c*. In this sample the average was 9.32 per cent. Highest, 10.81 per cent.; lowest, 8.57 per cent.; difference between highest and lowest, 2.24 per cent. Since no such differences exist in the available, the impression is created that with the lower results the exact directions of the method of determining soluble P_2O_5 , so far as extracting it with water on the filter is concerned, have not been followed. In all acid phosphates containing iron and alumina it is absolutely necessary to wash on the filter with small quantities of water at a time and letting each addition run off before another is made. A small quantity dissolves while a large one precipitates, which being caught on the filter is carried into the reduced. In States where the soluble P_2O_5 is given a higher value than the reduced, care here is very necessary to secure justice to the manufacturers. In States where both soluble and reduced are classified as available and together assigned the same value no such injustice will be done.

(4) The insoluble determinations are on the whole satisfactory. In *a* the average being 2.38 per cent.; highest, 2.60 per cent.; lowest, 2.17 per cent.

In *b*, when the insoluble is very small, larger proportional discrepancies exist. Average, .46 per cent.; highest, .85 per cent.; lowest, .20 per cent. In *c* the average is 4.19 per cent.; highest, 4.73 per cent.; lowest, 3.71 per cent. A difference between the highest and lowest, 1.02 per cent.; an amount too great in scientific work.

The above discrepancies may result from a different interpretation of the prescribed method, which says: Wash the residue of the treatment with water into 150 cc., flask with 100 cc. of strictly neutral ammonium citrate solution of 1.09 density, shed and add the filter paper, cork the flask securely, *place in a water-bath with constant temperature of 65°C. and digest for thirty minutes at this temperature with frequent shakings, &c.* The following letter from Dr. Dabney, of North Carolina, first calling our attention to this point is here given in order to show how two different interpretations may be placed upon the wording of this method and different results obtained thereby.

RALEIGH, March 26, 1887.

MY DEAR SIR: As chairman of the Phosphoric Acid Committee of the A. O. A. C., I beg to call your attention to the great importance of a better defined method for the digestion with ammonium citrate.

The way it reads now a man may try fairly to follow the method and still get results considerably at variance with those of another trying equally as hard to do right.

The words (see p. 49 of last published methods, paragraph 4) "place in a water bath with constant temperature of 65° C. and digest for thirty minutes at this temperature with frequent shakings" are susceptible of too varied interpretation. We have heretofore interpreted this as meaning "Warm the bath to 65° C., place the flask in this bath for thirty minutes," &c.; others, as Dr. Jenkins, if I understand him, hold that it means, "Place the flask in a cold bath and heat to 65° C., then count thirty minutes from time it reaches 65° C., &c. Others think time ought to be allowed for contents of flask to reach 65° C., &c.

These different ways of treating different phosphates make differences varying from one-half to one and one-half per cent. on the available.

Take the case of our and Jenkins's ways and compare them.

A given fertilizer gives us 4.18 per cent. insoluble, working our ways; Jenkins's way, gives us 3.59 per cent. of insoluble; or, quoting from Mr. Battles's report to me—

"This insoluble was placed in cold bath and heated with one lamp, with following results:

Bath.	Time.
18° C	10.15
30	10.20
45	10.30
30	10.40
65	10.45

"Digestion was continued for thirty minutes, or till 11.15. Flask was shaken every five minutes from 10.15.

"We see then that the flask remained thirty minutes more than usual, and this at a temperature averaging that in the old Washington method.

"The method à la Jenkins gave .59 per cent. P_2O_5 , less than that before.

"To have a quantitative method with no more definite directions than the above is to my mind utterly foolish, and well calculated to bring discrepancies into results."

Yours truly,

CHAS. W. DABNEY, JR.

Prof. W. C. STUBBS,

Kenner, La.

We quite agree with Dr. Dabney, and here recommend that this clause be so amended as to convey the exact meaning of this Association.

III. Your committee recommends, in conclusion, the continuance of the present general method for the determination of phosphoric acid, subject, of course, to such minor modifications as your wisdom may determine. It would, besides the needed amendment already alluded to, call particular attention of the official chemists and

their assistants to the necessity of following in the minutest detail whatever method may be adopted by this Convention, in order to gain the most perfect unanimity of results, thus securing the confidence of the public in our work.

IV. Since most of the members of this Association are, or will be, connected with experiment stations under the operation of the new Hatch bill, which we hope will be available by the beginning of another year; it may not be inappropriate to again call attention to the experiments of Dr. Paul Wagner to establish by soil tests the relative manurial value of the different forms of phosphoric acid, and to devise analytical methods for determining in the laboratory what will be the approximate manurial values in the field. Accurate experiments of a most extensive nature are required before we can render agriculture the assistance which is expected of us. To answer a farmer that we can tell the commercial but not the agricultural value of a fertilizer is a confession that brings grief, since the agricultural value, after all, gives the commercial. This question is made more serious recently by the introduction into our markets of the phosphate slag, a by-product in the Thomas-Gilchrist process of making steel. This basic slag is on our market, and both the manufacturer and farmer are demanding of us to assign it its proper place in our agricultural wealth. A sample taken from a lot recently imported into New Orleans from Glasgow, Scotland, gave, on analysis by official method: Reduced phosphoric acid, 5.37 per cent.; insoluble phosphoric acid, 11.14 per cent.; total phosphoric acid, 16.51 per cent. This slag is said to have a high agricultural value, while our methods of analyses show only one-third available.

These questions must be solved, and it seems to your committee that the present is a most opportune time for the adoption of plans looking to concerted action in the conduct of such experiments as will ultimately throw light on this important subject.

WM. C. STUBBS, *Chairman.*

W. E. MOSES.

The report being open for discussion, Professor LORD called attention to the indefinite directions as to the manner of heating the citrate solution during its action on the phosphate. He had received quite different directions from two members in reply to an inquiry for interpretation of the method. One had stated that the flask containing the citrate was to be placed in water which was to be rapidly raised to 65° C., and the other that the water was to be at 65° C. when the flask was put in.

After some discussion the directions were modified so as to read as they appear in the appendix.

Professor FEEB objected to the term "gentle heat" instead of "boil gently."

Professor LORD suggested that the form of flask and its size were important, and proposed an Erlenmeyer flask holding 200-240 cc.

The question of the use of a filter-pump in filtering the precipitate was brought up, and it was agreed to be desirable and necessary.

Professor GASCOYNE inquired as to whether more definite directions should not be given as to the preparation of the sample. He uses a 20-mesh sieve and a tight tin box; Dr. Jenkins uses a 25-mesh. The necessity for tightness of sifting-box was due to the ease with which moisture is gained or lost, depending, as Professor Stubbs showed, on the climatic conditions under which different chemists worked. In Louisiana the least exposure to the air is accompanied by gain.

The use of hydrochloric acid and chlorate met with opposition from many members, and called out some positive opinions.

Dr. JENKINS found it especially bad with castor pomace, and several chemists were unable to get all the P_2O_5 in solution in this way.

Professor MYERS said :

The working of the present method of determining the total P_2O_5 by HCl and $KClO_3$ in my hands is highly unsatisfactory. It has been next to impossible for me to extract all of the P_2O_5 by this method. I have found in most cases that more P_2O_5 can be obtained by the use of $Mg(NO_3)_2$ than by the method at present in force.

Personally I am in favor of returning to the use of the $Mg(NO_3)_2$ as the method for future use for the oxidation of organic matter.

I have never had the trouble with this reagent complained of by other gentlemen. The evaporation and burning off both proceed quietly, without bumping or spirting, and the process is free from the difficulties which follow the use of HCl and $KClO_3$.

I grant freely that in the hands of other chemists the present system may be a success, but am quite positive that at least, so far as I am concerned, a change is desirable. It strikes me that it is desirable to allow the chemist considerable latitude, as there is a variety of fertilizing materials in our markets, and it may not be possible in many cases to secure correct results. Besides this, as we are fully aware, a process successfully carried out by one person or in one laboratory may present serious or almost insurmountable difficulties to another. From some cause—you may call it the personal coefficient if you wish—it is next to impossible for chemists to secure concordant results by different methods. One can excel by the use of one process while another may be forced to employ a different method to secure equally correct results. Whether this be due to the personal error of the chemists, or to the impossibility of having equally accurate apparatus in all laboratories, or to both, is not important at present. The fact remains and we should not ignore its existence.

I am, therefore, most heartily in favor of giving more latitude in the methods used for destroying the organic matter and for estimation of the total P_2O_5 .

This can be accomplished by permitting optional methods, which is certainly desirable.

Professor SCOVELL moved that the use of nitric acid be substituted for HCl and $KClO_3$.

Professor STUBBS moved to amend by the use of HCl and $MgNO_3$.

Liberty of action in the matter seemed to be most desirable, and the motion, amended to the use of either solvent, was passed, and in consequence the section containing this provision was ordered to be somewhat modified.

Mr. CHAZAL desired the shredding of the first filter paper to be dispensed with, and it was agreed to as unnecessary, but the rubbing up

of the acid phosphate with small quantities of water for the extraction of soluble, especially on high-grade goods, was deemed to be advisable.

The report was then recommitted.

Dr. McMURTRIE then presented, by unanimous consent, the report of the committee to consider the communication of the Illinois State Board of Agriculture, as follows:

Your committee, to whom was referred the matter of the request of the State Board of Agriculture of Illinois, that this Association adopt (1) "a uniform series of blanks for use of all interested in inspection of commercial fertilizers," and (2) "a clearly expressed definition of the term commercial fertilizer," have to report that it appears that in the conditions of the laws of the different States it is impracticable for this Association to take action upon these points. Only methods for taking samples, making analyses, and stating results can be recommended with any satisfaction to all concerned.

WM. McMURTRIE.

WM. C. STUBBS.

M. A. SCOVELL.

Committee.

Professor CHAZAL desires that something should be done for uniformity in branding sacks, form of labels, blanks, method of drawing samples.

Dr. McMURTRIE said one year's experience in Illinois had shown a necessity for it.

Professor MYERS thought the matter not in the scope of the Association, and that no attempts should be made to influence legislation.

Dr. CHAZAL moved that the report be recommitted, with instructions to the committee to take into careful consideration the matters proposed and report at the next annual meeting.

He stated that he believed that the subjects proposed merited a more careful consideration by the Association than it had been possible to give them.

That the objection made, that such an inquiry was beyond the scope of the Association, which had no power to compel State legislatures or boards of control to adopt its recommendations, would apply with equal force to the consideration of methods of analysis. That the Association did not have any power to enforce the adoption by any State control of its methods of analysis; it only gives to certain methods the stamp of its approval and recommends their adoption for use.

That correct methods of sampling are certainly as essential as correct and uniform methods of analysis to the attainment of uniform results.

If any of the subjects proposed for the consideration of the Association should, after careful deliberation, be considered by the committee to be beyond the scope of the Association, it might so report, with a statement of its reasons for such action.

That the object and effect of the motion was not to commit the Association in any way, but merely to have these matters settled definitely, once for all, after careful consideration, and thus avoid the necessity of dealing with the subjects in part year after year.

Professor MACFARLANE said that Canada was laboring under the same difficulties, and that he would like to see some action.

It was moved and seconded to recommit the report for consideration by the committee, who are to report next year. Passed.

Mr. RICHARDSON then moved, and it was seconded and adopted, that all committees on method of analysis should recommend forms of statement.

The regular order of business having been taken up,

Mr. RICHARDSON, chairman, read the report of the Committee on Potash, as follows :

REPORT OF THE COMMITTEE ON POTASH.

In the absence of the remaining members of the committee on potash I have the honor to present the following report of the work which has been accomplished during the past year :

In the winter five samples of potash salts and potash fertilizers were distributed to members of the Association and others interested who had previously informed the committee that they would undertake the work. They consisted of—

- (1) Chemically pure potassic chloride.
- (2) Pure commercial potassic sulphate.
- (3) Commercial muriate.
- (4) Kainite.
- (5) Superphosphate with potash.

In reply results were received from nine laboratories and eleven analysts, as follows :

Analyst.	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.	
	Official.	Gladding.	Official.	Gladding.	Official.	Gladding.	Official.	Gladding.	Official.	Gladding.
A ¹							13.70		2.93	
A ²					56.76		13.73		3.12	
A ³					56.24		13.44		2.96	
B.....					56.68	56.10	13.62		2.87	2.90
					56.68	56.15	13.95	13.24	2.98	3.04
					57.08		12.95*			
C.....							13.07*			
						56.57		14.06		3.00
						56.66		14.00		3.19
D.....					55.94	55.72	13.56	12.92	2.96	2.71
E.....					55.88	55.73	13.16	13.16	2.97	2.74
F.....	63.10	63.14	53.65	53.68	53.89	54.25	13.60	13.35	2.65	2.75
G.....	62.19	62.09	53.92	54.04	56.44	56.48	13.35	13.45	2.71	2.70
H.....	62.61	62.45	53.66	53.99	58.22	56.96	13.68	13.87	3.18	3.27
I.....					56.65	56.87				
Highest.....	63.14	63.17	54.04	54.04	58.22	56.96	13.95	14.06	3.18	3.27
Lowest.....	62.61	62.45	53.65	53.68	53.89	54.25	13.16	12.92	2.65	2.70
Mean.....	62.94	62.94	53.86	53.83	56.37	56.15	13.58	13.49	2.93	2.98
Difference.....	.53	.72	.39	.36	4.33	2.71	.79	1.14	.53	.57

*Washed with Gladding's solution.

These results, while showing close agreement among a few of the analysts, contain figures in other cases which are far from what they should be. It would perhaps be fair to state that the latter were the work of persons not as well up in potash determinations as some of our older members and to express regret that many of our best analysts did not contribute any work. The averages, I believe, may fairly be considered as correct or close approximations to the true amount of potash in the specimens, and it will be seen that a majority of the analysts are in agreement with these figures and that the extremes which are so far apart occur in only two or three in-

stances; still at the best the results hardly present the accuracy desired. The necessity for careful investigation on the part of each analyst into his method of manipulation and repetition of the analyses in cases where the results do not agree with the averages are suggested as the best means of improving our work.

The Lindo-Gladding method has proved extremely satisfactory and seems to be fast taking the place of the more tedious method previously in use. Its recognition by the Association as the standard for the ensuing year is recommended with retention of the old method for cases where the former seems inapplicable.

No information of importance has appeared in the journals during the past year as far as the committee are aware, and no suggestions have been communicated to them by members of the Association. They can only recommend, as has been said, the retention of the principles applied during the past season.

CLIFFORD RICHARDSON,
Chairman.

Dr. WILEY then read the following abstract of a method for the determination of potash lately adopted by the French Association of Chemists:

ABSTRACT OF THE REPORT ON THE ESTIMATION OF POTASH BY THE COMMITTEE OF THE FRENCH ASSOCIATION OF SUGAR CHEMISTS.

The sample of fertilizer being properly prepared, 10 or 50 grams are taken, according to the percentage of potash which it is supposed to contain. The sample is subjected to ignition at a low temperature for the purpose of driving off the ammonia and to destroy organic matters. If the fertilizer is a liquid and contains ammonia, instead of submitting it to calcination there is added to it 2 to 3 grams of caustic magnesia, and it is then boiled until reduced to half its volume.

The calcined sample is dissolved in hot distilled water, decanted upon a filter, and washed until exhausted. After the washings are cooled the volume is made up to 500 cc., or to a liter. Take of this solution a quantity representing 1 to 2 decigrams of potash, make the solution slightly acid with hydrochloric acid to transform the bases into chlorides. Add then, drop by drop, a quantity of bichloride of platinum, sufficient not only to precipitate the potash but also the soda, the lime, the magnesia, the baryta, and the strontia which may be present. The analyst need not bother himself about other bodies present, such as sulphuric acid, phosphoric acid, silica, alumina, iron, &c. The liquid is evaporated on a sand bath, in a porcelain dish, to a pasty consistence. After cooling, the mass is digested for a few hours with a mixture of 95 per cent. alcohol and ether, 9 parts of alcohol to 1 of ether. The mass is carefully rubbed with a pestle in order to insure the complete solution of the chloro-platinates of soda, lime, magnesia, &c. Afterwards it is washed upon a smooth filter with the same mixture until the washings are perfectly clear and colorless. When the precipitate of the chloro-platinates, collected upon the filter, is partially dried, the vessel containing the wash water is removed, and there is placed under the funnel a porcelain dish, under which a lamp is placed. The precipitate is now treated with boiling distilled water until the chloro-platinate is completely dissolved. What remains upon the filter paper is ordinarily silica or iron.

In a porcelain dish there is placed a solution of formiate of sodium in sufficient quantity to reduce all of the platinum of the bichloride employed. This solution is carried to the boiling point, and is poured slowly into the boiling solution of the chloro-platinate upon which the formiate at once reacts, reducing the platinum to the metallic state in the form of a black powder. Afterwards a few drops of chlorohydric acid are added to the liquid, and it is boiled for a few moments in order to concentrate it and to agglutinate the platinum. The liquid is decanted upon a smooth filter, which gives but little ash on incineration. The metallic platinum is washed

44 REPORT ON COMMUNICATION OF FERTILIZER EXCHANGE.

upon the filter paper with boiling water until it contains no chloride, which is ascertained by treating a drop of the filtrate with silver nitrate.

The chloro-platinate may also be reduced by hydrogen, and the platinum obtained by this method is easier to wash and dry than by the method just given. The impure chloro-platinate of potassium is introduced into a small glass tube drawn out at one end. This tube is fitted to a hydrogen apparatus, the current of hydrogen being carefully dried. When the air is all driven out, the tube is lightly heated. The chloro-platinate is reduced and the tube contains a mixture of platinum sponge, chloride of potassium, and some other foreign matters precipitated by the alcohol at the same time with the chloro-platinate. The mixture is washed several times, dried, and weighed. The increase in the weight of the tube gives the weight of the spongy platinum derived from the decomposition of the chloro-platinate, and from this is easily determined the weight of potash contained in the sample analyzed.

REAGENTS EMPLOYED IN THE ESTIMATION OF POTASH.

Bichloride of platinum.—This solution should contain 10 grams of the platinum salt in each 100 cc.

Solution of sodic formate.—This solution should contain 10 per cent. of the formate; 35 cc. should be taken for each 10 cc. of the bichloride of platinum employed. The weight of platinum multiplied by .4786 gives the weight of potash.

Remarking on the report of the committee, almost all the members expressed their satisfaction with the Lindo-Gladding method.

Mr. FARRINGTON had found it would not work with wood ashes.

The report was then adopted making the Lindo-Gladding the leading method for the ensuing year, and the convention adjourned until Thursday at 10 a. m.

THURSDAY MORNING.

In the absence of the president the convention was called to order by the secretary, who nominated Professor Lupton as temporary chairman, which motion was seconded and carried.

The report of the Committee on Nitrogen being in regular order, it was delayed by unanimous consent to listen to the report of the committee to whom the communication of Mr. de Ghequier was referred.

The committee reported as follows:

REPORT OF THE COMMITTEE ON THE COMMUNICATION OF MR. DE GHEQUIER, SECRETARY OF THE NATIONAL FERTILIZER EXCHANGE.

Your committee have considered the communication of Mr. de Ghequier, secretary of the National Fertilizer Exchange, and beg leave to present the following report:

(1) That as regards uniform and accurate methods of sampling, your committee recognizes the great importance of the question, and recommends that it be referred to the committee already appointed for the consideration of the same subject.

(2) That as regards the use of uniform methods in determining nitrogen where nitrates are present, such methods have already been adopted by the Association.

(3) That as regards the other points suggested, report of analysis to manufacturer prior to publication, the revision, where desired, in cases of protest where such revision has not been previously been made, your committee would suggest that such a course of action, which is already practiced at many stations, is eminently desirable, and

should be commended to the attention of any of our members who have not been in the habit of following it.

(4) That it seems to your committee that it is somewhat doubtful whether the question of valuations is a subject within the scope of the Association, and your committee would therefore suggest that the matter be referred to the committee previously mentioned.

(5) In regard to the circular which has been offered as a part of the communication, your committee cannot see how the Association is concerned in questions of this character. But that as regards the particular matter it referred to, your committee would suggest that from the facts which have been brought out it is evident that the determinations in question were not made on the same sample, and it is further doubtful whether the two samples were representatives of the same lot of goods.

E. H. JENKINS.

P. E. CHAZAL.

W. J. GASCOYNE.

Committee.

The report was received and adopted.

Mr. CHAZAL moved that a committee be appointed by the chair to nominate officers for the ensuing year. This motion was seconded and passed, and the chair named Drs. Wiley, Scovell, and Gascoyne.

The Committee on Nitrogen then reported as follows:

REPORT OF THE COMMITTEE ON NITROGEN.

As required by the constitution of the Association, the Committee on Nitrogen herewith presents its report. The report covers (1) a brief notice of new methods for the determination of nitrogen proposed during the year; (2) results of work done during the past year by the committee and members of the Association, and (3) recommendations for the next year.

NEW METHODS FOR THE DETERMINATION OF NITROGEN.

Jodlbaur (Chem. Centralb., **17**, 433, J. S. C. I., **5**, 510) finds that when benzoic acid is employed in place of sugar as in the Kjeldahl method, when nitrates are present, as recommended by Asboth, the results are far too low. The author bases his method on an observation by Kjeldahl, that in his process the nitrogen in amines is readily converted into ammonia. The nitric acid is first converted into a nitrophenol, and subsequently reduced by zinc dust. For this purpose 0.2 to 0.5 gram of the substance is treated with 20 cc. of concentrated sulphuric acid and 2.5 cc. of phenol-sulphonic acid (100 cc. contains 50 grams of phenol) and then with 2 to 3 grams of zinc dust and a few drops of platinic chloride solution. The action is complete in about four hours. It is more rapid when phosphoric acid is mixed with the sulphuric acid.

Stutzer and Reitmaier (Rep. Anal. Chem. **7**, 4-6) finds that the method of Jodlbaur does not give good results when the manure contains a large percentage of nitrates, or when the substance examined is sodium or potassium nitrate; but by a slight modification, satisfactory results can be obtained even with nitrates themselves.

It is of great importance that the phenol-sulphonic acid should not be allowed to act upon compact masses of the substance.

One gram of the material is treated in a flask with 25 cc. of water and evaporated to dryness in an air bath at 100-110° C. This distributes the nitrates evenly throughout the mass. After cooling, 50 cc. of sulphuric acid containing 20 grams of phenol per liter is added. This converts the nitrates into nitrophenol. After standing for a few minutes, 2 to 3 grams of zinc dust and 1 or 2 drops of metallic mercury are added and the mixture boiled for about one and one-half hours. This converts the nitro-

phenol into amido-phenol, and then into sulphate of ammonia. The process is then completed in the usual way.

The writer made a number of tests with this method on the samples sent out by the committee and on pure potassium nitrate, with the following results:

	No. 4.	No. 5.	No. 6.	Pot. nit. c. p.
No. 1	3.24	3.06	2.57	13.74
No. 2	3.30	2.97	2.59	13.81
No. 3	3.27	3.03	2.63	13.79
Mean				
Theory	3.27	3.02	2.59	13.78
	3.28	3.04	2.58	13.84

These results show that when this method is carefully carried out it gives very accurate results, with fertilizers containing nitrates and with pure salts.

Professor Scovell of this committee, in a letter to the writer, describes the following modifications of the Jodlbaur-Kjeldahl method: .7 gram of potassium nitrate was placed in a Kjeldahl flash, 30 cc. of sulphuric acid added; then 3 cc. of phenol-sulphonic acid (50 grams phenol to 100 cc. sulphuric acid), and 3 grams of zinc dust and 2 drops of platinic chloride solution. After the mixture began boiling and fumes ceased 0.7 gram of mercuric oxide were added and the operation finished as usual.

The following results were obtained by Professor Scovell, on committee's samples and pure potassium nitrate:

	No. 4.	No. 5.	No. 6.	Potassium nitrate, c. p.
No. 1	3.30	2.94	2.49	13.70
No. 2	3.10	2.92	2.49	13.75
No. 3		2.92	2.52	
Mean	3.20	2.93	2.50	13.73
Theory	3.28	3.04	2.58	13.84

Care should be taken that the reaction is not too great. When lower oxides of nitrogen are present some escape. To avoid this loss the following modification was tried with good results. Salicylic acid method: 0.7 gram of substance is put in a Kjeldahl flash; then 30 cc. sulphuric acid containing 2 grams of salicylic acid, then zinc dust, &c., as usual.

The following results were obtained by Professor Scovell and the writer on the above modification, except that the writer first dissolved in water as recommended by Stutzer and Reitmaier (Rep. Anal. Chem., 7, 4-6):

	Number 4.	Number 5.	Number 6.	Potassium nitrate, c. p.
M. A. Scovell	3.21	2.97	2.55	13.60
	3.32	2.99	2.61	13.78
		3.05		13.85
				13.82
				13.83
				13.82
Mean	3.27	3.00	2.58	13.80
W. J. Gascoyne	3.23	2.95	2.56	13.73
	3.33	3.04	2.52	13.82
	3.25	3.00	2.60	13.80
Mean	3.27	2.99	2.56	13.78
Theory	3.28	3.04	2.58	13.84

From the results obtained by the above method, we believe that it is applicable for the estimation of nitrogen in all forms.

In the annual report of the New Jersey Agricultural Experiment Station for 1896 is published a paper by Dr. A. T. Neale on "The examination and comparison of analytical methods for the determination of nitrogen." In reference to the Kjeldahl method, he says :

"No difficulty was experienced in oxidizing the most refractory substance in from one to three hours. When care was taken to continue the digestion until a perfectly colorless solution was obtained, the addition of potassium permanganate did not appear necessary; its absence also seemed to lessen the liability of the solution to bump."

When caustic soda was used the boiling was perfectly smooth; with caustic potash, however, the bumping of the solution is so serious as to make it difficult to finish the determination. A comparison of the results (between the soda-lime and Kjeldahl methods) warrants the following conclusions:

The average determinations of one hundred and twenty samples of complete fertilizers show that higher percentages of nitrogen were secured by the Kjeldahl process; the average difference for the whole number of samples between the results from these two methods is five hundredths of one per cent. Of the twenty-five samples of high grade organic nitrogenous material analyzed the average percentage of nitrogen is identical by both methods.

In ground bones, dissolved bones, and miscellaneous materials the average determinations of twenty-seven samples by Kjeldahl's method were seven-hundredths of one per cent. lower than by the soda-lime process.

The Kjeldahl method secured slightly higher percentages of nitrogen in coarse fodder samples.

M. Raulin (Bull. Soc. Chimique, **47**, No. 2, page 92; Chem. News, **55**, 147) describes a modification of Dumas's method for the determination of total nitrogen in organic matter. The method consists of an apparatus for generating carbonic acid, on Deville's continuous system, from marble and hydrochloric acid. This apparatus transmits a current of carbonic acid (regulated by pinchcocks) through the combustion-tube. This is a tube of copper, 180 cm. in length and 18 mm. in diameter, surrounded by four brass jackets. Each of these jackets is 10 cm. in length, and is fitted with two tubulures by which the jackets communicate with each other through caoutchouc tubes. Two of these jackets are at the ends of the combustion-tube, whilst the two others are placed equidistant in the intervening space. During the combustion a current of cold water passes through the jackets to cool the central tube. This central tube communicates with an apparatus for collecting the gas.

The apparatus is used as follows: A spiral cylinder of copper wire gauze about 6 cm. long is introduced into the tube, so that the anterior extremity will be 10 cm. from the anterior jacket, then by means of a long dry glass funnel introduce 60 grams oxide of copper; then the mixture of the organic matter and oxide of copper. It is first mixed with a little copper oxide in fine powder and 20 grams of the oxide in grains to .8 gram of the material; the funnel is then rinsed out with a little oxide in grains.

In the same manner a sample of another organic substance is introduced in the second interval of the tube between the second and third jacket, with a second cylinder of copper gauze and oxide. A third sample is introduced into the third interval. The tube is then placed in the furnace, a current of carbonic acid is passed in to clear the tube, and when the residue of the gas not absorbable by caustic alkali which enters the graduated tube does not exceed $\frac{1}{4}$ cc. in a quarter of an hour a current of water is passed through the jacket. The combustion of the first sample is then started working from the front backwards. When the gas no longer continues to increase the volume of gas is read off. The combustion of the second and third samples is then proceeded

with in the same manner. A formula is given for the calculation of the percentage of nitrogen.

RESULTS OF WORK DONE DURING THE YEAR.

Last October your committee sent to nineteen official and nine commercial chemists six samples for nitrogen determination.

Samples No. 1-3 prepared for the purpose of comparing the soda-lime and Kjeldahl methods, and samples No. 4-6 for the purpose of thoroughly testing the Ruffe and copper-oxide methods.

In sample No. 6, members were requested to determine the nitrogen present as ammonia, as nitrates, and as organic nitrogen.

The following is a description of the samples:

No. 1. Dried blood, 13.82 per cent. nitrogen.

No. 2. Acid phosphate and dried blood, containing 2.76 per cent. of nitrogen.

No. 3. Acid phosphate, dried blood, and cotton-seed meal, containing 3.30 per cent. of nitrogen.

No. 4. Acid phosphate and c. p. nitrate of soda, containing 3.28 per cent. of nitrogen.

No. 5. Acid phosphate, dried blood, and c. p. nitrate of soda, containing 3.04 per cent. of nitrogen.

No. 6. Acid phosphate, dried blood, c. p. nitrate of soda, and c. p. sulphate of ammonia, containing 2.58 per cent. of nitrogen. No. 6 contains 1.06 per cent. of nitrogen from ammonia salts, .82 per cent. from nitrates, and .70 per cent. from organic material.

We regret to say that only eight official and two commercial chemists have reported on the samples.

The results obtained are given in the following tables:

SODA-LIME METHOD.

	No. 1.	No. 2.	No. 3.
A.....	13.50	2.85	3.09
C.....	14.20	2.80	3.35
D.....	14.23	3.00	3.13
E.....	13.49	2.97	3.06
H.....	13.95	2.80	3.29
I.....	13.80	3.17	3.30
K.....	13.44	2.78	3.01
Average.....	13.79	2.90	3.18

KJELDAHL METHOD.

A.....	13.44	2.87	3.11
B.....	13.95	2.74	3.37
C.....	14.03	2.48	3.36
E.....	13.86	2.82	3.27
F.....	14.04	2.83	3.30
G.....		2.87	3.21
H.....	13.90	2.85	3.26
I.....	13.86	2.85	3.25
K.....	13.46	2.73	3.22
Average.....	13.82	2.79	3.26

RUFFLE METHOD.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
A.....	13.40	2.85	3.09	3.30	3.12	2.60
B.....				3.08	2.91	2.53
C.....	14.28	3.07	3.64	3.39	2.82	2.50
D.....				3.04	2.81	2.54
E.....	13.83	3.24	3.16	2.70	2.91	2.57
G.....						2.55
H.....	13.96	2.82	3.29	3.32	2.97	2.59
I.....	13.88	2.81	3.28	2.92	2.69	2.26
K.....	13.37	2.77	3.19	2.31	2.77	2.45
Average.....	13.78	2.92	3.26	3.01	2.87	2.51

COPPER-OXIDE METHOD.

B.....				3.28	3.04	2.59
F.....				3.30	3.02	2.57
H.....	13.92	2.87	3.30	3.29	3.02	2.57
Average.....	13.92	2.87	3.30	3.29	3.03	2.58

METHODS OTHER THAN OFFICIAL

A.....	13.50	2.90	3.10	3.40	3.15	2.60
E.....	13.44	2.57	3.05	3.30	3.14	2.52
F.....				3.38	3.04	2.61
H ¹				3.30	3.04	2.59
H ²				3.27	3.02	2.59
H ³				3.27	2.99	2.56
I.....				3.27	3.00	2.53
Average.....	13.47	2.73	3.08	3.31	3.05	2.58

METHODS USED.

- A. Original Ruffle.
 E. Original Ruffle, substituting sugar for the c. and s. mixture.
 H¹. Official Ruffle, substituting sugar for the c. and s. mixture.
 H². Stutzer & Reitmaier's modification of the Kjeldahl method.
 H³ and I. Scovell's salicylic acid method.
 F. Kjeldahl using 1 gram of substance, 1 gram benzoic acid, 1 gram metallic mercury, 2½ grams zinc and 25 cc. sulphuric acid. In other respects the treatment was similar to the ordinary method.

Nitrogen in sample No. 6.

	Nitrogen as ammonia.	Nitrogen as nitrates.	Organic nitrogen.	Total nitrogen.
A.....	1.02	.83	.72	2.57
G.....	1.02	.69	.85	2.55
H.....	1.04	.80	.72	2.56
Average.....	1.03	.77	.76	2.56

In obtaining these results A and H used the following method: One gram of the sample was exhausted with water and filtered. In the filtrate nitrogen from ammonia salts was determined by distillation with calcined magnesian oxide, and nitrogen from nitrates in the same fluid, by distillation with caustic potash and zinc and iron filings. The exhausted residue was dried and the nitrogen in organic matter determined by the soda-lime method.

Averages.

SODA-LIME METHOD.

Sample.	Number of determi- nations.	Average.	Highest.	Lowest.	Difference.
No. 1.....	7	13.79	14.23	13.44	.79
No. 2.....	7	2.90	3.17	2.80	.37
No. 3.....	7	3.18	3.35	3.01	.34

KJELDAHL METHOD.

No. 1.....	7	13.81	14.04	13.44	.40
No. 2.....	8	2.77	2.87	2.48	.39
No. 3.....	8	3.26	3.37	3.11	.26
No. 4.....	4	3.29	3.38	3.27	.11
No. 5.....	4	3.01	3.04	2.99	.05
No. 6.....	4	2.58	2.61	2.56	.05

RUFFLE METHOD.

No. 1.....	5	13.78	14.28	13.40	.88
No. 2.....	5	2.92	3.24	2.81	.33
No. 3.....	5	3.28	3.64	3.09	.55
No. 4.....	7	3.01	3.39	2.70	.69
No. 5.....	7	2.87	3.12	2.69	.43
No. 6.....	8	2.51	2.60	2.28	.34

COPPER-OXIDE METHOD.

No. 4.....	3	3.29	3.30	3.28	.02
No. 5.....	3	3.03	3.04	3.02	.02
No. 6.....	3	2.58	2.59	2.57	.02

Nitrogen in sample No. 6.

	Number of determi- nations.	Average.	Highest.	Lowest.	Difference.
Nitrogen as ammonia.....	3	1.03	1.04	1.02	.02
Nitrogen as nitrates.....	3	.77	.83	.69	.14
Organic nitrogen.....	3	.76	.85	.71	.13
Total nitrogen.....	3	2.53	2.57	2.55	.02

In connection with these results, the following points may be mentioned :

The averages agree reasonably well with the calculated results, but the differences between the determinations are too great to pass unnoticed.

By the soda-lime method the average of sample No. 1 is .03 lower than the mean of all the determinations by the official methods on this sample.

On sample No. 2 the average is .14 higher than theoretical results.

On sample No. 3 the average is .12 lower than calculated results.

By the Kjeldahl method, the average of sample No. 1 is identical with the mean of all tests on this sample.

On sample No. 2 the average is .03 higher than theoretical.

On sample No. 3 the average is .02 lower than theoretical.

On samples Nos. 4, 5, and 6, by the modifications of the Kjeldahl method noticed in this report, the results are as follows :

On sample No. 4 the average is .01 higher than theoretical.

On sample No. 5 the average is .03 lower than theoretical, and on sample No. 6 the average and theoretical results are identical.

The results by the Ruffle method are not very satisfactory. Many have obtained theoretical results, while others have reported determinations so much below the calculated results that we are satisfied that it is not altogether the fault of the method.

On sample No. 1 the average is .04 lower than the mean of all determinations.

On sample No. 2 the average is .06 higher than theoretical.

On sample No. 3 the average is .01 lower than theoretical.

On sample No. 4 the average is .27 lower than theoretical. Omitting these very out-of-the-way determinations, the average would only be .05 lower than calculated.

On sample No. 5 the average is .15 lower than theoretical.

On sample No. 6 the average is .07 below theoretical, and by leaving out one determination, which is much too low, the average would be only .04 below theoretical.

The results by the copper-oxide method are very satisfactory.

On sample No. 3 the average is .01 higher than theoretical; sample No. 4 is .01 lower, and on sample No. 6 the average and theoretical results are identical.

On sample No. 6 the following results were obtained: On nitrogen and ammonia the average is .03 below theoretical; on nitrogen as nitrates the average is .05 below, and for organic nitrogen the average is .06 higher than calculated results.

RECOMMENDATIONS.

After the careful consideration of the results obtained, the committee desires to make the following recommendations:

(1) That the copper-oxide method be continued.

(2) That the Ruffle method be continued, except that sugar be substituted for the charcoal and sulphur mixture.

(3) That the present official Kjeldahl and soda-lime methods be used where no nitrates are present.

(4) That while on account of the want of experience of the members of this Association in the use of the salicylic acid modification of the Kjeldahl method as recommended by Prof. Scovell, the committee does not feel authorized to recommend its adoption as an official method, but desire to present it to the careful consideration of the Association, in the belief that its simplicity and adaptability to all the contingencies of the fertilizer analysis are such as to render advisable its adoption and use.

Respectfully submitted,

W. J. GASCOYNE, *Chairman.*
M. A. SCOVELL.

Professor M. A. SCOVELL, a member of the nitrogen committee, then read the following paper:

THE KJELDAHL METHOD APPLICABLE TO DETERMINATION OF NITROGEN IN NITRATES.

In looking over the field for investigation, as a member of your Committee on Nitrogen, it seemed to me the one object to be obtained was some modification of the Kjeldahl method, so as to make it applicable in all cases of nitrogen determinations.

The absolute method as adopted by the Association is all that can be desired so far as quantitative accuracy is concerned. But the great length of time it takes to estimate nitrogen by this process is a cause for looking for a simpler and more rapid method.

The Ruffle method, as adopted by the Association, needs at least to be perfected. In my hands the results have been discouraging. Especially is this so where pure nitrates

are examined. In estimating pure KNO_3 by the method as adopted by the Association, the following results were obtained :

Nitrogen.	
	Per cent.
1	11. 12
2	12. 56
3	12. 04
4	11. 68

A modification, whereby sugar was used in place of charcoal, gave 12.88. Theory, 13.83.

Where small quantities of nitrates are present this method works better. But it seems to me a method that will not give satisfactory results on pure nitrates is to be used with caution. Furthermore, the manipulations required and the time consumed in the determinations, like that of the absolute method, make a more rapid method desirable.

As to rapidity of execution the Kjeldahl method is all that can be desired.

The benzoic-acid method has been investigated by Mr. Spencer, of the Department of Agriculture, with very unsatisfactory results (see Bulletin No. 12). M. Jodlbaur (Chem. Centr., 1886, 433) also finds the results by this method far too low; but he made a series of experiments with phenol-sulphuric acid and obtained satisfactory results. The method is given in the committee's report. Stutzer and Reitmaier claim that Jodlbaur's method does not give accurate results when the manure contains large quantities of nitrates or when NaNO_3 or KNO_3 are examined, and suggest adding water to the fertilizer, evaporating in the Kjeldahl flask, and then heating with sulphuric acid containing phenol. This, they claim, distributes the nitrates evenly throughout the mass.

In our hands M. Jodlbaur's method on pure potassium nitrate gave the following results :

	Per cent.
Nitrogen	13. 70
	13. 75
	13. 74
Average	13. 73
Theoretical	13. 84

The average is 0.11 per cent. below the theoretical. Not all that could be desired, yet nearly approaching satisfactory results.

We next tried this method on sodium nitrate. For this purpose samples Nos. 4, 5, and 6 of the nitrogen committee were selected.

Sample No. 4 is a mixture of acid phosphate and sodium nitrate, containing 3.28 per cent. nitrogen.

	Per cent.
Nitrogen found	3. 10
	3. 30
Average	3. 20

Sample No. 5, acid phosphate, blood and pure sodium nitrate, containing 3.04 per cent. nitrogen.

	Per cent.
Nitrogen found	2.94 2.92 2.93
Average	2.93

Sample No. 6, acid phosphate, blood, sulphate of ammonia, and pure sodium nitrate, containing 2.58 per cent. nitrogen.

	Per cent.
Nitrogen found	2.49 2.49 2.52
Average	2.50

Being convinced that the loss of nitrogen was due to its escape when the phenol mixture was added to the nitrate, I endeavored to overcome this difficulty without having to resort to the tedious process of dissolving the nitrates in water, evaporating, and spreading over the flask as Stutzer and Reitmaier recommend.

Salicylic acid dissolves readily in sulphuric acid without rise of temperature or vigorous reaction.

Taking advantage of this we continued our experiments, substituting salicylic acid for phenol-sulphuric acid, and also adding 0.7 grams of mercuric oxide after digestion for sometime to hasten oxidation.

Our first experiment was on pure potassium nitrate. This contained .07 per cent. water, theoretical per cent. nitrogen 13.83. 0.7 grams of potassium nitrate was brought into a Kjeldahl flask, and dissolved in 30 cc. sulphuric acid. Two grams salicylic acid were added, and contents shaken; then 3 grams zinc-dust gradually added and 2 drops of a platonic chloride solution. The whole was first gradually heated, until danger of frothing was over, then the temperature increased until the liquid boiled rapidly in the flask. After vigorous reaction ceased, 0.7 grams mercuric oxide were added and the boiling continued until the liquid was colorless. This generally took about one hour from the time digestion first begun. In the distillation the official Kjeldahl method was followed.

By this method the following results were obtained on the potassium nitrate:

	Per cent.
Nitrogen found	13.60 13.78 13.85 13.82 13.83 13.83 13.82 13.82 13.83
Average	13.80
Theoretical	13.83

Committee samples Nos. 4, 5, and 6, containing sodium nitrate, and, as described before, were analyzed by this method with the following results:

	Sample No. 4.	Sample No. 5.	Sample No. 6.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Nitrogen found	3.21	2.97	2.55
	3.32	2.99	.....
	.....	3.05	2.61
Average	3.27	3.00	2.58
Theoretical	3.28	3.04	2.58

The next experiment was the determination of nitrogen in a sample of pure NaNO_3 , containing sugar:

	Per cent.
Nitrogen found	3.37
Nitrogen found by the absolute method	3.38
	3.38

In the selection of samples to test the method due regard was taken to have the nitrogen in all forms, as found in fertilizers, after testing the method first by pure potassium nitrate. Samples Nos. 4, 5, and 6 were mixed last September, almost a year ago, and the sample with sugar over one year. This certainly would give the nitrogen in a form more nearly representing the nitrogen fertilizer mixtures than samples freshly mixed. In sample No. 6 all three of the forms of nitrogen were represented. The method seems to give very accurate results, whether pure salts are under examination or the various mixtures representing fertilizer mixtures.

For ease of manipulation and rapidity of work this method especially recommends itself, and I believe it will prove to be satisfactory in every respect.

Dr. WILEY then read the following:

ABSTRACT OF THE REPORT OF THE COMMITTEE ON THE DETERMINATION OF NITROGEN IN FERTILIZERS, PRESENTED TO THE FRENCH ASSOCIATION OF SUGAR CHEMISTS, JULY, 1887.

The committee consisted of Messrs. Deherain, Julie, Aubin, and Dupont.

NITROGEN.

A preliminary examination was recommended to determine the nature of the nitrogen in a sample.

AMMONIA SALTS.

A small portion is mixed with powdered soda lime in the cold. If ammonia salts are present the odor of ammonia is observed.

NITRIC ACID.

Nitric acid is detected by sulphuric acid and ferrous sulphate in the aqueous extract of the sample. If the aqueous solution be too highly colored, alcohol of 80 per cent. strength should be employed as the solvent.

Brucine may also be used to detect the nitric acid. Mix 1cc. aqueous solution of brucine with the same quantity of the solution of the fertilizer; add carefully 1 cc. strong sulphuric acid, letting it run slowly down the side of the test tube. If nitric acid be present a rose color varying to yellow and very persistent will be produced.

ORGANIC NITROGEN.

Nitrogen existing in organic compounds may be detected by heating the residue from the aqueous extraction with soda lime.

QUANTITATIVE ESTIMATION OF NITROGEN.

The committee divide the process into eight parts, viz.:

- (1) Estimation of organic nitrogen.
- (2) Estimation of ammoniacal nitrogen.
- (3) Estimation of nitric nitrogen.
- (4) Procedure in case of a fertilizer containing nitrogen in its three forms.
- (5) Procedure in case of a fertilizer containing organic and ammoniacal nitrogen.
- (6) Procedure in case of a fertilizer containing organic and nitric nitrogen.
- (7) Procedure in case of a fertilizer containing ammoniacal and nitric nitrogen.
- (8) Estimation of total nitrogen.

QUANTITATIVE ESTIMATION OF ORGANIC NITROGEN.

Combustion with soda lime and the Kjeldahl method are recommended. The standard acid is recommended to be of such a strength that 1 cc. may correspond to one-hundredth of a gram of nitrogen. For this purpose 35 grams of monohydric sulphuric acid or 45 grams of crystallized oxalic acid are required to the liter.

QUANTITATIVE ESTIMATION OF AMMONIACAL NITROGEN.

The process of Boussingault is recommended, namely: the evolution of the ammonia by means of lime, potash, or magnesia.

MANIPULATION.

In a flask of 500 cc. capacity is placed half a gram of the material to be analyzed, together with 30 cc. of distilled water and 2 grams of caustic magnesia. This flask is connected with the condensing apparatus and the distillation is continued until 60 to 100 cc. have passed over. The titration is made with standard alkali, using litmus or lacmoid as an indicator. The distillation apparatus of Aubin is recommended, in which the distillation is made *per ascensum*, the greater part of the vapor of water being condensed and returned into the flask, while the ammonia, more volatile, escapes in such a way as to secure the whole of the ammonia in a very small portion of the water. This renders the titration more exact.

QUANTITATIVE ESTIMATION OF NITRIC NITROGEN.

The process of Schloessing is recommended. It rests upon the transformation of nitric acid into dioxide of nitrogen.

The reaction which takes place is as follows:



The dioxide of nitrogen which is set free is measured and from its volume the weight of nitrogen is calculated. When the matter to be analyzed is not very pure, or when it is mixed with a soluble carbonate, it is possible that other gases beside the dioxide of nitrogen may be set free. In this case it is necessary that a correction to the total volume should be made.

When the operation is finished the dioxide of nitrogen can be absorbed by introducing into the tube containing it a piece of ferrous sulphate. The tubes should be shaken sufficiently long and vigorously to insure the complete absorption of the dioxide of nitrogen. The reading of the gaseous volume before and after the introduction of the ferrous sulphate will give the volume of gas corresponding to the dioxide of nitrogen.

Further detailed directions for conducting the operation and calculating the weight of nitrogen are given in the report of the committee.

ESTIMATION OF NITROGEN IN ITS THREE STATES IN A COMPLEX FERTILIZER.

1. Weigh 10 grams of the matter, place in a flask containing water, shake, and allow to dissolve, filter and wash until the volume of the wash water amounts to 500 cc.

(a) Take 50 cc. of the liquid and treat it for ammonia by Boussingault's method.

(b) On another part of the liquid, estimate the nitric nitrogen by Schloesing's process.

2. A new sample of the fertilizer is taken and the ammoniacal and nitric nitrogen which it contains destroyed, as follows:

The ammonia is driven off by boiling the sample in a porcelain dish with caustic magnesia and a sufficient quantity of water. Afterwards evaporate to dryness, cover the sample with some oxalic acid, and moisten. Dry in an oven at 110° for an hour and a half. All of the nitric nitrogen is transferred into dioxide of nitrogen, which escapes. The organic nitrogen which remains is estimated by soda-lime or by the Kjeldahl process.

FERTILIZER CONTAINING ORGANIC NITROGEN AND NITRIC NITROGEN.

1. The nitric nitrogen is estimated in the aqueous solution by the method of Schloesing.

2. From 1 to 2 grams of the substance the nitric acid is driven off by oxalic acid in the manner described above, and the organic nitrogen estimated in the residue by means of the soda-lime or Kjeldahl method.

FERTILIZER CONTAINING ORGANIC NITROGEN AND AMMONIACAL NITROGEN.

1. The ammoniacal nitrogen is determined by the method of Boussingault.

2. For the determination of the organic nitrogen 1 to 2 grams of the fertilizer are boiled in a porcelain dish with magnesia and a sufficient quantity of water to drive off the ammonia. Evaporate to dryness and estimate the organic nitrogen by the soda-lime or Kjeldahl process.

FERTILIZER CONTAINING AMMONIACAL NITROGEN AND NITRIC NITROGEN.

Weigh out 10, 20, or 30 grams, and add enough water to make up to 500 cc. Take 50 or 100 cc. and estimate the ammoniacal nitrogen in the manner already described. On another portion of the liquid the nitric nitrogen is estimated by the method of Schloesing.

ESTIMATION OF TOTAL NITROGEN.

The absolute method is recommended. Two methods of procedure are indicated:

(1) The apparatus may be freed of air by means of carbonic dioxide, or (2) the air may be exhausted by means of a mercury pump.

The committee gives preference to the latter procedure.

Full details of the manipulation are given by the committee.

The report of the Committee on Nitrogen being open for discussion, the Kjeldahl method was taken up.

Professor SCOVELL described his results in determining nitrates by the use of phenol and salicylic acid, and Dr. GASCOYNE said that he had been able to confirm them.

Mr. FARRINGTON then described his method with phenol, as follows :

*THE JODLBAUR MODIFICATION OF THE KJELDAHL METHOD [CHEM. ZTG., 1887
2, 12] WHEN NITRATES ARE PRESENT.*

To 1 gram substance in a dry, pear-shaped flask of about 250 cc. capacity, add 50 cc. of a solution containing 50 grams phenol in 1,000 cc. common sulphuric acid.

After standing some minutes, with frequent shaking, add 2 to 3 grams zinc-dust and about 7 grams mercury monoxide.

Heat the flask at first over a low flame, as its contents may foam badly ; finally increase the heat till the acid liquid in the flask boils vigorously.

Continue the boiling till the solution is nearly colorless, then add potassium permanganate and proceed as in the usual Kjeldahl method for determining nitrogen.

I use common sulphuric acid, as there is less danger of driving off nitric acid when it is added to a nitrate than by using c. p. sulphuric acid.

The common sulphuric acid also contains less nitrogen than any c. p. acid that I have been able to get.

I have made a determination of nitrogen by this modification of the Kjeldahl method, comparing it with one made by the absolute or copper-oxide method on forty different samples of commercial fertilizers, containing total nitrogen from $2\frac{1}{4}$ to $6\frac{1}{4}$ per cent., of which from $\frac{1}{4}$ to $2\frac{1}{4}$ per cent. was in the form of nitrates.

The difference in results by the two methods was in 55 per cent. of the analyses less than .1 per cent. ; in 24 per cent. of the analysis, between .1 and .15 per cent. ; in 14 per cent. of the analysis, between .15 and .20 per cent. ; in 7 per cent. of the analysis, between .20 and .24 per cent.

Professor SCOVELL said he found less nitrogen with phenol than with salicylic acid.

Mr. CHAZAL then moved that Professor Scovell's method be adopted as an addition to the Kjeldahl method, and it was adopted.

The absolute method was also sanctioned for another year, and, after discussion, the Ruffle method substituting sugar for charcoal and soda lime for slaked lime.

The soda-lime method was also retained as being necessary for some chemists not having facilities for working in other ways.

The report, with amendments, was then recommitted and, on its return by the committee, adopted as a whole.

Miscellaneous business being in order, the committee on amendments to the constitution reported a recommendation that the second section should read as follows :

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership, and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to a vote in the Association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the Association by presenting proper credentials and signing the constitution. All analytical chemists and others interested in the objects of the Association may attend its meetings and take part in its discussions, but shall have no vote in the Association.

The recommendation was accepted and unanimously adopted.

Professor MYERS then moved to refer the method of electing officers to a committee to report at next meeting, which was carried.

Professors Myers, Stubbs, and Gascoyne were appointed on the committee.

Mr. RICHARDSON moved, and it was adopted, that hereafter the names of persons making analyses of the official samples be attached to their results on publication.

Professor RISING moved that a committee be appointed on wines or fermented liquors; carried.

Professor STUBBS moved that a committee be appointed on sugar and sugar products; carried.

The committee to recommend officers then reported the following list, which was unanimously elected :

For President : Mr. P. E. Chazal.

For Vice-President : Dr. W. J. Gascoyne.

For Secretary : Mr. Clifford Richardson.

For Executive Committee : Dr. E. H. Jenkins, Prof. J. A. Myers.

Professor STUBBS then moved and it was unanimously carried—

That the thanks of the Association are tendered to the honorable Commissioner of Agriculture for his kindness to and interest in the Association, and for his continued generosity in publishing and distributing its proceedings, which have largely aided in extending its influence.

The convention then adjourned *sine die* to await the call of the Executive Committee.

APPENDIX A.

OFFICIAL METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR 1887-'88.

METHODS FOR DETERMINING PHOSPHORIC ACID AND MOISTURE.

(1) *Preparation of sample.*—The sample should be well intermixed and properly prepared, so that separate portions shall accurately represent the substance under examination, without loss or gain of moisture.

(2) *Determination of moisture.*—(a) In potash salts, nitrate of soda, and sulphate of ammonia heat 1 to 5 grams at 130° C. till the weight is constant, and reckon water from the loss. (b) In all other fertilizers heat 2 grams, or if the sample is too coarse to secure uniform lots of 2 grams each, 5 grams, for five hours at 100° in a steam bath.

(3) *Water-soluble phosphoric acid.*—Bring 2 grams on a filter, add a little water, let it run out before adding more water, and repeat this treatment cautiously until no phosphate is likely to precipitate in the filter. If the washings show turbidity after passing the filter clear up with acid. When the substance is nearly washed in this manner it is transferred to a mortar and rubbed with a rubber-tipped pestle to a homogeneous paste (but not further pulverized), then returned to the filter and washed with water until the filtrate measures not less than 250 cc. Mix the washings. Take an aliquot (usually corresponding to $\frac{1}{4}$ or $\frac{1}{2}$ gram of the substance) and determine phosphoric acid, as under total phosphoric acid.

(4) *Citrate-insoluble phosphoric acid.*—Wash the residue of the treatment with water into a 200 cc. flask with 100 cc. of strictly neutral ammonium citrate solution of 1.09 density, prepared as hereafter directed. Cork the flask securely and place it in a water bath, the water of which stands at 65° C. (The water bath should be of such a size that the introduction of the cold flask or flasks shall not cause a reduction of the temperature of the bath of more than 2° C.) Raising the temperature as rapidly as practicable to 65° C., which is subsequently maintained, digest with frequent shakings for thirty minutes from the instant of insertion, filter the warm solution quickly (best with filter-pump), and wash with water of ordinary temperature. Transfer the filter and its contents to a capsule, ignite until the organic matter is destroyed, treat with 10 to 15 cc. of concentrated hydrochloric or nitric acid, digest over a low flame until the phosphate is dissolved, dilute to 200 cc., mix, pass through a dry filter, take an aliquot and determine phosphoric acid as under total.

In case a determination of citrate-insoluble phosphoric acid is required in non-acidulated goods, it is to be made by treating 2 grams of the phosphatic material, without previous washing with water, precisely in the way above described, except that in case the substance contains much animal matter (bone, fish, &c.) the residue insoluble in ammonium citrate is to be treated by one of the processes described below.

(5) *Total phosphoric acid.*—Weigh 2 grams and treat by one of the following methods: (1) Evaporation with 5 cc. magnesium nitrate, ignition, and solution in acid. (2) Solution in 30 cc. concentrated nitric acid with a small quantity of hydrochloric acid.

(3) Add 30 cc. concentrated hydrochloric acid, heat, and add cautiously and in small quantities at a time about 0.5 gram of finely pulverized potassium chlorate.

Boil gently until all phosphates are dissolved and all organic matter destroyed; dilute to 200 cc.; mix and pass through a dry filter; take 50 cc. of filtrate; neutralize with ammonia (in case hydrochloric acid has been used as a solvent add about 15 grams dry ammonium nitrate or its equivalent). To the hot solutions for every decigram of P_2O_5 that is present, add 50 cc. of molybdic solution. Digest at about $65^\circ C.$ for one hour, filter, and wash with ammonium nitrate solution. (Test the filtrate by renewed digestion and addition of more molybdic solution.) Dissolve the precipitate on the filter with ammonia and hot water and wash into a beaker to a bulk of not more than 100 cc. Nearly neutralize with hydrochloric acid, cool, and add magnesia mixture from a burette; add slowly (one drop per second), stirring vigorously. After fifteen minutes add 30 cc. of ammonia solution of density 0.96. Let stand several hours (two hours is usually enough). Filter, wash with dilute ammonia, ignite intensely for ten minutes, and weigh.

(6) Citrate-soluble phosphoric acid. The sum of the water-soluble and citric insoluble subtracted from the total gives the citrate-soluble.

PREPARATION OF REAGENTS.

(1) *To prepare ammonium citrate solution.*—Mix 370 grams of commercial citric acid with 1,500 cc. of water; nearly neutralize with crushed commercial carbonate of ammonia; heat to expel the carbonic acid; cool; add ammonia until exactly neutral (testing by saturated alcoholic solution of coralline) and bring to volume of two liters. Test the specific gravity, which should be 1.09 at $20^\circ C.$, before using.

(2) *To prepare molybdic solution.*—Dissolve 100 grams of molybdic acid in 400 grams or 47 cc. of ammonia of specific gravity 0.96, and pour the solution thus obtained into 1,500 grams or 1,250 cc. of nitric acid of specific gravity 1.20. Keep the mixture in a warm place for several days, or until a portion heated to $40^\circ C.$ deposits no yellow precipitate of ammonium phospho-molybdate. Decant the solution from any sediment, and preserve in glass-stoppered vessels.

(3) *To prepare ammonium nitrate solution.*—Dissolve 200 grams of commercial ammonium nitrate in water and bring to a volume of two liters.

(4) *To prepare magnesia mixture.*—Dissolve 22 grams of recently ignited calcined magnesia in dilute hydrochloric acid, avoiding excess of the latter. Add a little calcined magnesia in excess, and boil a few minutes to precipitate iron, alumina, and phosphoric acid, filter, add 280 grams of ammonium chloride, 700 cc. of ammonia of specific gravity 0.96, and water enough to make the volume of two liters. Instead of the solution of 22 grams of calcined magnesia 110 grams of crystallized magnesium chloride ($MgCl_2 \cdot 6H_2O$) may be used.

(5) *Dilute ammonia for washing.*—One volume ammonia of specific gravity 0.96 mixed with three volumes of water, or usually one volume of concentrated ammonia with six volumes of water.

(6) *Nitrate of magnesia.*—Dissolve 320 grams of calcined magnesia in nitric acid, avoiding an excess of the latter; then add a little calcined magnesia in excess, boil; filter from excess of magnesia, ferric oxide, &c., and bring to volume of two liters.

METHODS OF DETERMINING POTASH.

METHOD OF LINDO AS MODIFIED BY GLADDING.

(1) *Superphosphates.*—Boil 10 grams of the fertilizer with 300 cc. of water for ten minutes. Cool the solution; add ammonia in slight excess, thus precipitating all phosphate of lime, oxide of iron, and alumina, &c., make up to 500 cc., mix thoroughly and filter through a dry filter; take 50 cc. corresponding to 1 gram, evaporate nearly to dryness, add 1 cc. of dilute H_2SO_4 (1 to 1), and evaporate to dryness and ignite to whiteness. As all the potash is in form of sulphate, no loss need be apprehended by

volatilization of potash, and a full red heat must be used until the residue is perfectly white. This residue is dissolved in hot water plus a few drops of HCl; 5 cc. of a solution of pure NaCl (containing 20 grams NaCl to the liter) and an excess of platinum solution (4 cc.) are now added, and the whole evaporated as usual. The precipitate is washed thoroughly with alcohol by decantation and on filter, as usual. The washing should be continued even after the filtrate is colorless. Ten cc. of the NH_4Cl solution prepared as above are now run through the filter. These 10 cc. will contain the bulk of the impurities, and are thrown away. A fresh portion of 10 cc. NH_4Cl is now run through the filter several times (five or six). The filter is then washed thoroughly with pure alcohol, dried, and weighed as usual. The platinum solution used contains 1 gram metallic platinum in every 10 cc.

(2) *Muriates of potash*.—In the analysis of these salts an aliquot portion, containing .500 gram, is evaporated with 10 cc. platinum solution plus a few drops of HCl, and washed as before.

(3) *Sulphate of potash, kainite, &c.*—In the analysis of these salts an aliquot portion containing .500 gram is taken, .250 gram of NaCl added, plus a few drops of HCl, and the whole evaporated with 15 cc. platinum solution. In this case special care must be taken, in the washing with alcohol, to remove all the double chloride of platinum and sodium. The washing should be continued for some time after the filtrate is colorless. Twenty-five cubic centimetres of the NH_4Cl solution are employed, instead of 10 cc., and the 25 cc. poured through at least six times to remove all sulphates and chlorides. Wash finally with alcohol, dry, and weigh as usual.

To prepare the washing solution of NH_4Cl , place in a bottle 500 cc. H_2O , 100 grams of NH_4Cl ; shake till dissolved. Now pulverize 5 or 10 grams of K_2PtCl_6 , put in the bottle, and shake at intervals for six or eight hours; let settle over night; then filter off liquid into a second bottle. The first bottle is then ready for a preparation of a fresh supply when needed.

ALTERNATE METHOD.

Pulverize the fertilizer (200 or 300 grams) in a mortar; take 10 grams, boil for ten minutes with 200 cc. water, and after cooling, and without filtering, make up to 1,000 cc., and filter through a dry paper. In this method, in case the potash is contained in organic compounds, like tobacco stems, cotton-seed hulls, &c., the substance is to be saturated with strong sulphuric acid and ignited in a muffle to destroy organic matter. If the sample have 10 to 15 per cent. K_2O (kainite), take 50 cc. of the filtrate; if from 2 to 3 per cent. K_2O (ordinary potash fertilizers), take 100 cc. of the filtrate. In each case make the volume up to 150 cc., heat to 100° , and add, drop by drop, with constant stirring, slight excess of barium chloride; without filtering, in the same manner, add barium hydrate in slight excess. Heat, filter, and wash until precipitate is free of chlorides. Add to filtrate 1 cc. strong ammonium hydrate, and then a saturated solution of ammonium carbonate until excess of barium is precipitated. Heat. Add now, in fine powder, 0.5 gram pure oxalic acid or 0.75 gram ammonium oxalate. Filter, wash free of chlorides, evaporate filtrate to dryness in a platinum dish, and, holding dish with crucible tongs, ignite carefully over the free flame below red heat until all volatile matter is driven off.

The residue is now digested with hot water, filtered through a small filter, and washed with successive small portions of water until the filtrate amounts to 30 cc. or more. To this filtrate, after adding two drops of strong hydrochloric acid, is added, in a porcelain dish, 5 to 10 cc. of a solution of 10 grams of platinic chloride in 100 cc. of water. The mixture is now evaporated on the water-bath to a thick syrup, or further treated with strong alcohol washed by decantation, collected in a Gooch crucible or other form of filter, washed with strong alcohol, afterwards with 5 cc. ether, dried for thirty minutes at 100°C. , and weighed.

It is desirable, if there is an appearance of white foreign matter in the double salt, that it should be washed, according to the previous method, with 10 cc. of the half-

concentrated solution of NH_4Cl , which has been saturated by shaking with K_2PtCl_6 , as recommended by Gladding.

The use of the factor 0.3056 for converting K_2PtCl_6 to KCl and 0.19308 for converting to K_2O is continued.

METHODS FOR THE DETERMINATION OF NITROGEN.

THE ABSOLUTE OR CUPRIC OXIDE METHOD.

The apparatus and reagents needed are as follows :

APPARATUS.

Combustion tube of best hard Bohemian glass, about 26 inches long and one-half inch internal diameter.

Azotometer of at least 100 cubic centimeters capacity, accurately calibrated.

Sprengel mercury air pump.

Small paper scoop, easily made from stiff writing-paper.

REAGENTS.

Cupric oxide (coarse).—Wire form ; to be ignited and cooled before using.

Fine cupric oxide.—Prepared by pounding ordinary cupric oxide in mortar.

Metallic copper.—Granulated copper or fine copper gauze reduced and cooled in stream of hydrogen.

Sodium bicarbonate.—Free from organic matter.

Caustic potash solution.—Dissolve commercial stick potash in less than its weight of water so that crystals are deposited on cooling. When absorption of carbonic acid ceases to be prompt solution must be discarded.

LOADING TUBE.

Of ordinary commercial fertilizers take 1 to 2 grams for analysis. In the case of highly nitrogenous substances the amount to be taken must be regulated by the amount of nitrogen estimated to be present. Fill tube as follows : (1) About 2 inches of coarse cupric oxide. (2) Place on the small paper scoop enough of the fine cupric oxide to fill, after having been mixed with the substance to be analyzed, about 4 inches of the tube ; pour on this the substance, rinsing watch glass with a little of the fine oxide and mix thoroughly with spatula ; pour into tube, rinsing the scoop with a little fine oxide. (3) About 12 inches of coarse cupric oxide. (4) About 3 inches of metallic copper. (5) About $2\frac{1}{2}$ inches of coarse cupric oxide (anterior layer). (6) Small plug of asbestos. (7) Eight-tenths to 1 gram of sodium bicarbonate. (8) Large, loose plug of asbestos ; place tube in furnace, leaving about 1 inch of it projecting ; connect with pump by rubber stopper smeared with glycerine, taking care to make connection perfectly tight.

OPERATION.

Exhaust air from tube by means of pump. When a vacuum has been obtained, allow flow of mercury to continue, light gas under that part of tube containing metallic copper, anterior layer of cupric oxide (see 5th above) and bicarbonate of soda. As soon as vacuum is destroyed and apparatus filled with carbonic acid gas, shut off the flow of mercury and at once introduce the delivery tube of the pump into the receiving arm of the azotometer and just below the surface of the mercury seal of the azotometer, so that the escaping bubbles will pass into the air and not into the azotometer, thus avoiding the useless saturation of the caustic potash solution.

When the flow of carbonic acid has very nearly or completely ceased, pass the delivery tube down into the receiving arm, so that the bubbles will escape into the azotometer. Light the jets under the 12-inch layer of oxide, heat gently for a few moments to drive out any moisture that may be present, and bring to red heat. Heat gradually mixture of substance and oxide, lighting one jet at a time. Avoid too rapid evolution of bubbles, which should be allowed to escape at rate of about one per second or a little faster.

When the jets under mixture have all been turned on, light jets under layer of oxide at end of tube. When evolution of gas has ceased turn out all the lights except those under the metallic copper and anterior layer of oxide, and allow to cool for a few moments. Exhaust with pump and remove azotometer before flow of mercury is stopped. Break connection of tube with pump, stop flow of mercury and extinguish lights. Allow azotometer to stand for at least an hour or cool with stream of water until permanent volume and temperature are reached.

Adjust accurately the level of the KOH solution in bulb to that in azotometer, note volume of gas, temperature, and height of barometer; make calculations as usual. The labor of calculation may be much diminished by the use of the tables prepared by Messrs. Battle and Dancy, of the North Carolina Experiment Station (Raleigh, N. C.).

The above details are, with some modifications, those given in the report of the Connecticut Station for 1879 (p. 124), which may be consulted for details of apparatus, should such details be desired.

DETERMINATION BY THE METHOD OF KJELDAHL.

REAGENTS AND APPARATUS.

(1) Hydrochloric acid whose absolute strength has been determined, (a) by precipitating with silver nitrate and weighing the silver chloride, (b) by sodium carbonate, as described in Fresenius's Quantitative Analysis, second American edition, page 680, and (c) by determining the amount neutralized by the distillate from a weighed quantity of pure ammonium chloride boiled with an excess of sodium hydrate.

(2) Standard ammonia whose strength, relative to the acid, has been accurately determined.

(3) "C. P." sulphuric acid, specific gravity 1.83, free from nitrates and also from ammonium sulphate, which is sometimes added in the process of manufacture to destroy oxides of nitrogen.

(4) Mercuric oxide, HgO , prepared in the wet way. That prepared from mercury nitrate cannot safely be used.

(5) Potassium permanganate tolerably finely pulverized.

(6) Granulated zinc.

(7) A solution of 40 grams of commercial potassium sulphide in one liter of water.

(8) A saturated solution of sodium hydrate free from nitrates, which are sometimes added in the process of manufacture to destroy organic matter and improve the color of the product. That of the Greenbank Alkali Company is of good quality.

(9) Solution of cochineal prepared according to Fresenius's Quantitative Analysis, second American edition, page 679.

(10) Burettes should be calibrated in all cases by the user.

(11) Digestion flasks of hard, moderately thick, well-annealed glass. These flasks are about 9 inches long, with a round, pear-shaped bottom, having a maximum diameter of $2\frac{1}{4}$ inches, and tapering out gradually in a long neck, which is three-fourths of an inch in diameter at the narrowest part, and flared a little at the edge. The total capacity is 225 to 250 cc.

(12) Distillation flasks of ordinary shape, 550 cc. capacity, and fitted with a rubber stopper and a bulb tube above to prevent the possibility of sodium hydrate being

carried over mechanically during distillation. This is adjusted to the tube of the condenser by a rubber tube.

(13) A condenser. Several forms have been described, no one of which is equally convenient for all laboratories. The essential thing is that the tube which carries the steam to be condensed shall be of block tin. All kinds of glass are decomposed by steam and ammonia vapor, and will give up alkali enough to impair accuracy. (See Kreussler and Henzold, *Ber. Berichte*, *XVII*, 34.) The condenser in use in the laboratory of the Connecticut Experiment Station, devised by Professor Johnson, consists of a copper tank supported by a wooden frame, so that its bottom is 11 inches above the work-bench on which it stands. This tank is 16 inches high, 32 inches long, and 3 inches wide from front to back, widening above to 6 inches. It is provided with a water-supply tube which goes to the bottom and a larger overflow pipe above. The block tin condensing tubes, whose external diameter is $\frac{3}{4}$ of an inch, seven in number, enter the tank through holes in the front side of it near the top, above the level of the overflow, and pass down perpendicularly through the tank and out through rubber stoppers tightly fitted into holes in the bottom. They project about $1\frac{1}{4}$ inches below the bottom of the tank, and are connected by short rubber tubes with glass bulb tubes of the usual shape, which dip into glass precipitating beakers. These beakers are $6\frac{1}{4}$ inches high, 3 inches in diameter below, somewhat narrower above, and of about 500 cc. capacity. The titration can be made directly in them. The seven distillation flasks are supported on a sheet-iron shelf attached to the wooden frame that supports the tank in front of the latter. Where each flask is to stand a circular hole is cut, with three projecting lips, which support the wire gauze under the flask, and three other lips which hold the flask in place and prevent its moving laterally out of place while distillation is going on. Below this sheet-iron shelf is a metal tube carrying seven Bunsen burners, each with a stop-cock like those of a gas-combustion furnace. These burners are of larger diameter at the top, which prevents smoking when covered with fine gauze to prevent the flame from striking back.

(14) The stand for holding the digestion flasks consists of a pan of sheet-iron 29 inches long by 8 inches wide, on the front of which is fastened a shelf of sheet-iron as long as the pan, 5 inches wide and 4 inches high. In this are cut six holes $1\frac{1}{2}$ inches in diameter. At the back of the pan is a stout wire running lengthwise of the stand, 8 inches high, with a bend or depression opposite each hole in the shelf. The digestion flask rests with its lower part over a hole in the shelf and its neck in one of the depressions in the wire frame, which holds it securely in position. Heat is supplied by low Bunsen burners below the shelf. With a little care the naked flame can be applied directly to the flask without danger.

THE DETERMINATION.

One gram of the substance to be analyzed is brought into a digestion flask with approximately 0.7 gram of mercuric oxide and 20 cc. of sulphuric acid. The flask is placed on the frame above described in an inclined position and heated below the boiling point of the acid for from 5 to 15 minutes, or until frothing has ceased. The heat is then raised till the acid boils briskly. No further attention is required till the contents of the flask have become a clear liquid, which is colorless or at least has only a very pale straw color. The flask is then removed from the frame, held upright, and, while still hot, potassium permanganate is dropped in carefully and in small quantity at a time till after shaking the liquid remains of a green or purple color. After cooling, the contents of the flask are transferred to the distilling flask with water, and to this 25 cc. of potassium sulphide solution are added, 50 cc. of the soda solution, or sufficient to make the reaction strongly alkaline, and a few pieces of granulated zinc. The flask is at once connected with the condenser and the contents of the flask are distilled till all ammonia has passed over into the standard acid contained in the precipitating flask previously described and the concentrated solution

can no longer be safely boiled. This operation usually requires from 20 to 40 minutes. The distillate is then titrated with standard ammonia.

The use of mercuric oxide in this operation greatly shortens the time necessary for digestion, which is rarely over an hour and a half in the case of substances most difficult to oxidize and is more commonly less than an hour. In most cases the use of potassium permanganate is quite unnecessary, but it is believed that in exceptional cases it is required for complete oxidation, and in view of the uncertainty it is always used. Potassium sulphide removes all mercury from solution and so prevents the formation of mercurio-ammonium compounds which are not completely decomposed by soda solution. The addition of zinc gives rise to an evolution of hydrogen and prevents violent bumping. Previous to use the reagents should be tested by a blank experiment with sugar, which will partially reduce any nitrates that are present which might otherwise escape notice.

The following modification must be used for the determination of nitrogen in substances which contain nitrates when it is desired to use this method.

DETERMINATION OF NITROGEN, INCLUDING THE NITROGEN OF NITRATES, BY A MODIFIED METHOD OF KJELDAHL.*

Bring from 0.7 to 1.4 grams of the substance to be analyzed into a Kjeldahl digesting flask, add to this 30.00 of sulphuric acid containing 2 grams of salicylic acid, and shake thoroughly. Then add *gradually* three grams of zinc-dust, shaking the contents of the flask at the same time. Finally, add two or three drops of platonic chloride solution and place the flask on the stand for holding the digestion flasks, where it is heated over a low flame until all danger from frothing has passed. The heat is then raised until the acid boils briskly, and the boiling continued until white fumes no longer pour out of the flask. This requires about five or ten minutes. Add now approximately 0.7 gram mercuric oxide and continue the boiling until the liquid in the flask is colorless, or nearly so. (In case the contents of the flask are likely to become solid before this point is reached add 10 cc. more of sulphuric acid.) Complete the oxidation with a little permanganate of potash in the usual way, and proceed with the distillation as described in the method above.

DETERMINATION BY THE RUFFLE METHOD.

PREPARATION OF REAGENTS.

- (1) *A standard solution of sulphuric acid*, half normal, or 19.968 grams SO_3 per liter.
- (2) *A standard solution of potassium hydrate*, half normal, or 27.991 grams KOH per liter.
- (3) *An alcoholic solution of cochineal*.
- (4) *Hyposulphite mixture*.—Prepared by mixing equal parts by weight of soda-lime and finely powdered crystallized sodium hyposulphite.
- (5) *Sugar and sulphur mixture*.—This is prepared by mixing equal parts by weight of finely powdered granulated sugar and flowers of sulphur.
- (6) *Ordinary granulated soda-lime*.

APPARATUS.

- (1) *Combustion tubes* of hard Bohemian glass, 20 inches long and $\frac{1}{4}$ inch internal diameter, drawn to a point.
- (2) *Three-bulb, 6-inch U tubes*, with glass stop-cock.
- (3) *Aspirator*.

PREPARATION.

- (1) Clean and fill the U tube with 10 cubic centimeters of standard acid.
- (2) Fit cork and glass connecting tube. Fill the tube as follows: (1) A loosely plug of asbestos, previously ignited, and then 1 to $1\frac{1}{4}$ inches of the hypsul-

* Described by Prof. M. A. Scovell.

phite mixture. (2) The weighed portion of the substance to be analyzed is intimately mixed with from 5 to 10 grams of the sugar and sulphur mixture. (3) Pour on a piece of glazed paper, or porcelain mortar, a sufficient quantity of the hyposulphite mixture to fill about 10 inches of the tube; then add the substance to be analyzed, as previously prepared; mix carefully and pour into the tube; shake down the contents of the tube; rinse off the paper or mortar with a small quantity of the hyposulphite mixture and pour into the tube; then fill up with soda-lime to within 2 inches of the end of the tube. (4) Place another plug of ignited asbestos at the end of the tube, and close with a cork. (5) Hold the tube in a horizontal position, and tap on the table until there is a gas channel all along the top of the tube. Make connection with the U tube containing the acid, aspirate, and see that the apparatus is tight.

The combustion.—Place the prepared combustion tube in the furnace, letting the open end project a little so as not to burn the cork. Commence by heating the soda-lime portion until it is brought to a full red heat. Then turn up slowly jet after jet toward the outer end of the tube, so that the bubbles come off two or three a second. When the whole tube is red hot and the evolution of the gas has ceased and the liquid in the U tube begins to recede towards the furnace, attach the aspirator to the other limb of the U tube, break off the end of the tube, and draw a current of air through for a few minutes. Detach the U tube and wash the contents into a beaker or porcelain basin, add a few drops of the cochineal solution, and titrate.

DETERMINATION BY THE SODA-LIME METHOD.

Select a tube of hard glass 14 to 16 inches long, draw one end of it to a fine point, and to the other end fit a cork, through which is passed a tube bent at right angles, the other end of which passes through a cork closing tightly one arm of a 6-inch three-bulbed U tube with glass stop-cock. Into the combustion tube first slip a loosely fitting plug of asbestos previously ignited, and then 1½ to 2 inches of soda-lime. Weigh out from 0.7 to 2.8 grams of the substance to be analyzed, and mix it on a piece of glazed paper or porcelain mortar with some finely pulverized soda-lime, and introduce the mixture into the combustion tube. The paper or mortar is then rinsed out with a small quantity of soda-lime and poured into the tube. The tube is then filled up to within 1 to 2 inches of the open end with granulated soda-lime, then with a plug of ignited asbestos. A free passage is formed for the evolved gases by holding the tube in a horizontal position and tapping gently on the table. Introduce the prepared combustion tube into the furnace, letting the open end project a little so as not to burn the cork, supporting the U tube by a clamp. The tube is then gradually heated, commencing at the fore part, nearest the cork, and progressing slowly towards the tail. The combustion should be conducted so as to obtain a steady and uninterrupted flow of gas. When properly carried out the acid in the U tube is never colored. When the acid begins to recede attach the aspirator to the other limb of the U tube, and start it slowly, then break off the point of the combustion tube and draw a current of air through the apparatus for a few minutes, in order to sweep all the ammonia into the acid.

Detach the U tube and wash the contents into a beaker or porcelain basin, add a few drops of an alcoholic solution of cochineal, and titrate.

The standard acid and alkali to be the same as that used in the Ruffie method.

METHOD FOR THE ANALYSIS OF CATTLE FOODS.

Hygroscopic moisture.—Dry 2 to 3 grams at 100° C. to constant weight.

Ash.—Char the substance at a low red heat, exhaust the charred mass with water, burn the insoluble residue, add the ash to the residue from the evaporation of the aqueous extract obtained above, dry the whole at 110°, and weigh. Determine carbonic acid and insoluble matter (sand and charcoal) in the product for the estimation of the pure ash.

Ether extract.—Pulverize the air-dry substance till all of it will pass through a sieve with not less than $\frac{1}{16}$ inch mesh; dry about 5 grams at 100° , and take about 2 grams for each extraction. Exhaust with anhydrous ether of specific gravity .720-.725, not less than eight hours continuously. Dry ether extract at 100° in a current of dry hydrogen to a constant weight.

Crude protein.—Determine nitrogen by the Kjeldahl method in the manner recommended by the Nitrogen Committee, and multiply the result by 6.25 for the crude protein.

Albuminoid nitrogen, Stutzer's method.—Prepare cupric hydrate as follows: Dissolve 100 grams of pure cupric sulphate in 5 liters of water, and add 2.5 cc. of glycerine; add dilute solution of sodium hydrate till the liquid is alkaline, filter, rub the precipitate up with water containing 5 cc. of glycerine per liter, and then wash by decantation or filtration till the washings are no longer alkaline. Then rub the precipitate up again in a mortar with water containing 10 per cent. of glycerine, thus preparing a uniform gelatinous mass that can be measured out with a pipette. Determine the quantity of cupric hydrate per 1 cc. of this mixture.

To 1 gram of the substance, pulverized as for the determination of the ether extract, add 100 cc. of water in a beaker, heat to boiling, or in case of substances rich in starch heat on the water bath ten minutes add a quantity of the cupric hydrate mixture containing 0.7 to 0.8 grams of the hydrate, stir thoroughly, filter when cold, wash with cold water, and without drying put the filter and its contents into the concentrated sulphuric acid for the determination of the nitrogen after Kjeldahl. For filtering use either Schleicher and Shull's No. 589 filter paper or Swedish paper, either of which contains so little nitrogen that it can be left out of account.

If the substance examined consists of seed of any kind or residues of seeds, such as oil cake or anything rich in alkaline phosphate, add a few cubic centimeters of a concentrated solution of alum just before adding the cupric hydrate, and mix well by stirring. This serves to decompose the alkaline phosphate, precipitating aluminum phosphate; if this is not done cupric phosphate and pure alkali may be formed, and the protein copper may be partially dissolved in this alkaline liquid.

Crude fiber, Weende method.—Pulverize as for the ether extract, and extract the fat, at least nearly completely. To 2 grams of the substance in an Erlenmeyer flask add 200 cc. of boiling 1.25 per cent. sulphuric acid, boil immediately and for thirty minutes continuously with as much rotary motion as may be necessary to keep all the substances that may tend to adhere to the sides of the flask in contact with the liquid, throw on a filter of finest linen, and rinse the flask and wash the contents of the filter thoroughly with boiling water. Wash the contents of the filter back into the flask with 200 cc. of a 1.25 per cent. solution of sodium hydrate, at once raise to boiling, and boil continuously for thirty minutes with rotary motion as above described, filter through a Gooch crucible or according to some similar device, and wash very thoroughly with boiling water. Such thorough washing has been found to be essential to success. Wash then with alcohol and finally with ether, dry at 110° , weigh, incinerate, and give the loss of weight for crude fiber.

*Crude fiber closed digestion method.**—Pulverize as for the ether extract, and extract the fat at least nearly completely from 2 grams of substance; allow the ether to evaporate, and transfer to a patent-stoppered beer-bottle with the aid of a funnel and 200 cc. of a solution of 4 per cent. hydrochloric acid in a wash-bottle. Cork, and after seeing that the material is thoroughly saturated with the acid, with none floating on the surface, place in a bath of boiling water of such a size that the neck of the bottle being covered with a copper ring with a suitable-sized hole the entire bottle, except the upper part of the neck, will be surrounded by the boiling water or steam. At intervals of five minutes the bottle is grasped about the neck with a cloth and given such a rotary motion as to stir up the entire contents and wash down the neck. This is preferable to ordinary shaking. The digestion is continued for one hour and the

* Described by Clifford Richardson.

acid then removed by filtration on finest washed linen, as in the preceding method, and the residue washed back with a wash-bottle into the bottle with 200 cc. of 4 per cent. solution of *sodio hydrate*, such as the granulated of the Greenbank Alkali Works. The digestion is then continued as before for one hour and the residue collected, as in the preceding method, and thoroughly washed with hot water, alcohol, and ether. It is dried at 110°, weighed, ignited at as low a heat as possible to prevent volatilization of any soda salts which may not have been removed, and the crude fiber calculated from the loss.

Statement of results.

	In the substance in its natural condition (or as received).	In the dry substance.
Moisture.....		
Ash.....		
Ether extract.....		
Crude fiber.....		
Crude protein.....		
Nitrogen: Total.....		
Albuminoid.....		

METHODS OF ANALYSES OF DAIRY PRODUCTS.

BUTTER.

MICROSCOPIC EXAMINATION.

Place a small portion of the fresh sample, taken from the inside of the mass, on a slide, add a drop of pure sweet oil, cover with gentle pressure, and examine with a $\frac{1}{4}$ to $\frac{1}{2}$ inch objective for crystals of lard, &c.

Examine same specimen with polarized light and selenite plate.

Pure fresh butter will neither show crystals nor a parti-colored field with selenite. Other fats, melted and cooled and mixed with butter, will usually present crystals and variegated colors with the selenite plate.

SPECIFIC GRAVITY.

Take a specific gravity flask, not graduated, the stopper of which carries a delicate thermometer, whose bulb occupies sensibly the center of the flask. The thermometer should be first compared with a standard instrument.

Clean the picnometer with water, alcohol, and ether; dry, be careful to remove all the ether vapor, and weigh.

Fill with distilled water, insert stopper, and place in vessel containing water which comes nearly to top of picnometer (without stopper); gradually raise the temperature of water in vessel containing flask until it is 40°.5–41° C.

The moment the thermometer of the picnometer marks 40° remove the flask, dry carefully, cover capillary safety-tube, and set in balance or desiccator to cool. Weigh when temperature falls nearly to that of balance room. Having determined the titre of the flask it is to be carefully dried, filled with the melted and filtered fat at a temperature below 40°, and the weight of the fat determined at 40°, as directed above.

MELTING-POINT.

Apparatus.—The apparatus, Fig. 1, consists of (1) an accurate thermometer, for reading easily tenths of a degree; (2) a less accurate thermometer for measuring the temperature of water in the large beaker glass; (3) a tall beaker glass, 35 cm. high and 10 cm. in diameter; (4) a test tube 30 cm. high and 3.5 cm. in diameter; (5) a stand for supporting the apparatus; (6) some method of stirring the water in the beaker—for example, a blowing bulb of rubber and a bent glass tube extending to near the bottom of the beaker; (7) a mixture of alcohol and water of the same specific gravity as the fat to be examined.

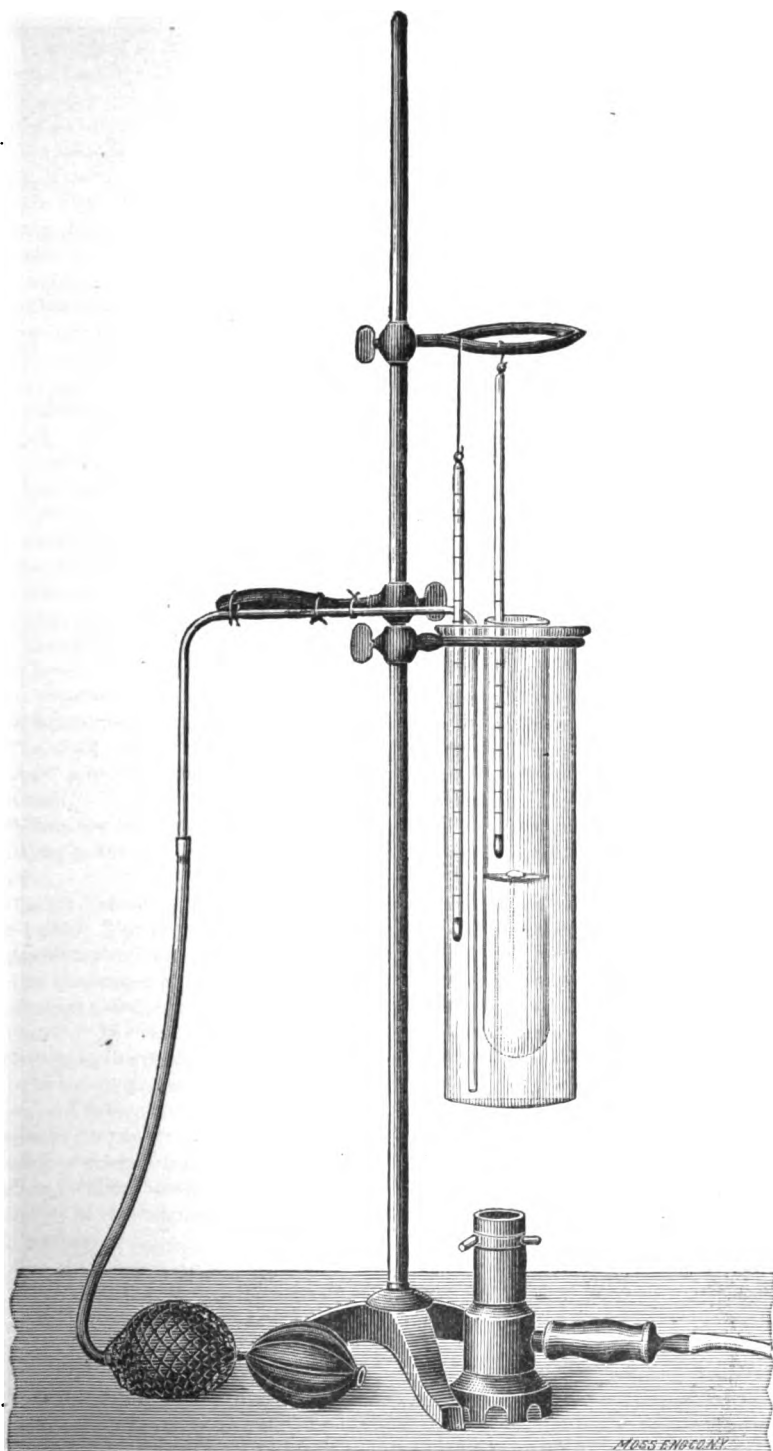


FIG. 1.

Manipulation.—The disks of the fat are prepared as follows: The melted and filtered fat is allowed to fall from a dropping tube from a height of 15 to 20 cm. on to a smooth piece of ice floating in water. The disks thus formed are from 1 to 1½ cm. in diameter and weigh about 200 milligrams. By pressing the ice under the water the disks are made to float on the surface, whence they are easily removed with a steel spatula.

The mixture of alcohol and water is prepared by boiling distilled water and 95 per cent. alcohol for ten minutes to remove the gases which they may hold in solution. While still hot the water is poured into the test-tube already described until it is nearly half full. The test-tube is then filled with the hot alcohol. It should be poured in gently down the side of the inclined tube to avoid too much mixing. If the tube is not filled until the water has cooled, the mixture will contain so many air bubbles as to be unfit for use. These bubbles will gather on the disk of fat as the temperature rises and finally force it to the top of the mixture.

The test tube containing the alcohol and water is placed in a vessel containing cold water, and the whole cooled to below 10° C. The disk of fat is dropped into the tube from the spatula, and at once sinks until it reaches a part of the tube where the density of the alcohol-water is exactly equivalent to its own. Here it remains at rest and free from the action of any force save that inherent in its own molecules.

The delicate thermometer is placed in the test tube and lowered until the bulb is just above the disk. In order to secure an even temperature in all parts of the alcohol mixture in the vicinity of the disk the thermometer is moved from time to time in a circularly, pendulous manner. A tube prepared in this way will be suitable for use for several days; in fact, until the air bubbles begin to attach themselves to the disk of fat. In no case did the two liquids become so thoroughly mixed as to lose the property of holding the disk at a fixed point, even when they were kept for several weeks.

In practice, owing to the absorption of air, it has been found necessary to prepare new solutions every third or fourth day.

The disk having been placed in position, the water in the beaker glass is slowly heated and kept constantly stirred by means of the blowing apparatus already described.

When the temperature of the alcohol-water mixture rises to about 6° below the melting-point, the disk of fat begins to shrivel, and gradually rolls up into an irregular mass.

The thermometer is now lowered until the fat particle is even with the center of the bulb. The bulb of the thermometer should be small, so as to indicate only the temperature of the mixture near the fat. A gentle rotary movement should be given to the thermometer bulb, which might be done with a kind of clockwork. The rise of temperature should be so regulated that the last 2° of increment require about ten minutes. The mass of fat gradually approaches the form of a sphere, and when it is sensibly so the reading of the thermometer is to be made. As soon as the temperature is taken, the test tube is removed from the bath and placed again in the cooler. A second tube, containing alcohol and water, is at once placed in the bath. It is not necessary to cool the water in the bath. The test tube (ice water being used as a cooler) is of low enough temperature to cool the bath sufficiently. After the first determination, which should be only a trial, the temperature of the bath should be so regulated as to reach a maximum about 1°·5 above the melting-point of the fat under examination.

Working thus with two tubes about three determinations can be made in an hour.

After the test tube has been cooled the globule of fat is removed with a small spoon attached to a wire before another disk of fat is put in.

VOLATILE ACIDS.

Take about 2.5 grams filtered fat in 200 cc. flask, to be used in subsequent distillation; add 2 cc. aqueous solution potassium hydrate containing .5 grams KOH per cc. Add 2 cc. 95 per cent. alcohol and heat on water bath, with occasional agita-

tion. Saponification is complete in a few minutes. Evaporate until alcohol is all driven off, using a current of air to remove alcoholic vapor. The flask is fitted with a delivery tube and condenser, as in Fig. 2. The delivery tube is carried up about 8 inches before it is bent to enter the condenser, and a bulb is blown in it just below the elbow, and this is filled with broken glass or glass wool.

The fatty acids are then set free with 20 cc. of a solution of phosphoric acid made by dissolving 200 grams glacial phosphoric acid in water and making up to one liter. Enough water is added to make the volume of liquid in the flask 70 cc. Distillation is continued until the distillate measures 50 cc., which is titrated with $\frac{N}{10}$ NaOH, using phenol-phthalein as indicator.

(Care should be taken to have the potash used free from carbonate. A potash containing carbonate saponifies a fat with great difficulty. In an instance where the saponification was taking place very slowly, the potash was found to contain 6.80 per cent. CO_2 , equal to 21.17 per cent. K_2CO_3 .)

SOLUBLE ACIDS.

The washings obtained in the process of estimating the insoluble acids, the description of which follows, are made up to one liter and an aliquot part taken for titration with one-tenth N. alkali, using phenol-phthalein as indicator.

METHOD FOR THE DETERMINATION OF SOLUBLE AND INSOLUBLE ACIDS.

REAGENTS.

1. A standard semi-normal hydrochloric-acid solution, accurately prepared.
2. A standard decinormal soda solution, accurately prepared; each 1 cc. contains .0040 grams of NaOH and neutralizes .0088 grams of butyric acid, $\text{C}_4\text{H}_8\text{O}_2$.
3. An approximately semi-normal alcoholic potash. Dissolve 40 grams of good stick potash in 1 liter of 95 per cent. alcohol, redistilled. The solution must be clear and the KOH free from carbonates.
4. A 1 per cent. solution of phenol-phthalein in 95 per cent. alcohol.

Saponification is carried out in rubber-stoppered beer-bottles holding about 250 cc.

About 5 grams of the melted butter fat, filtered and freed from water and salt, are weighed out by means of a small pipette and beaker, which are reweighed after the sample has been taken out and run into a saponification bottle; 50 cc. of the semi-normal potash is added, the bottle closed and placed on the steam bath until the contents are entirely saponified, facilitating the operation by occasional agitation. The alcoholic potash is measured always in the same pipette and uniformity further insured by always allowing it to drain the same length of time, viz, 30 seconds. Two or three blanks are also measured out at the same time and treated in the same way.

In from 5 to 30 minutes, according to the nature of the fat, the liquid will appear perfectly homogeneous, and when this is the case the saponification is complete, and the bottle may be removed and cooled. When sufficiently cool the stopper is removed and the contents of the flask rinsed with a little 95 per cent. alcohol into an Erlenmeyer flask of about 250 cc. capacity, which is placed on the steam bath, together with the blanks, until the alcohol has evaporated.

Titrate the blanks with semi-normal HCl, using phenol-phthalein as an indicator. Then run into each of the flasks containing the fat acids 1 cc. more semi-normal HCl than is required to neutralize the potash in the blanks. The flask is then connected with a condensing tube 3 feet long, made of small glass tubing, and placed on the steam bath until the separated fatty acids form a clear stratum on the surface of the liquid. The flask and contents are then allowed to become thoroughly cold, ice water being used for cooling.

The fatty acids having quite solidified, the contents of the flask are filtered through a dry filter paper into a liter flask, in the manner shown in Fig. 3, care being taken not to

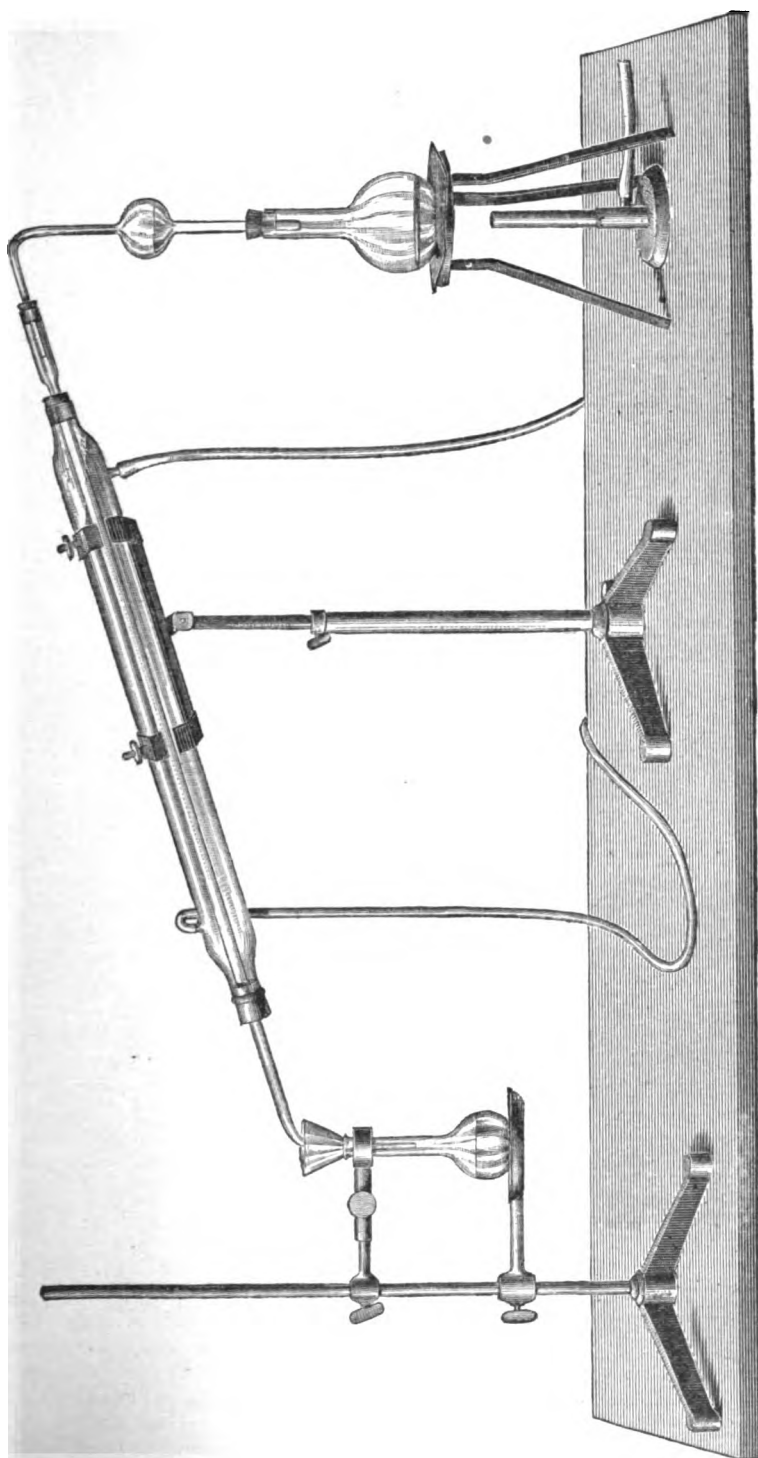


FIG. 2.

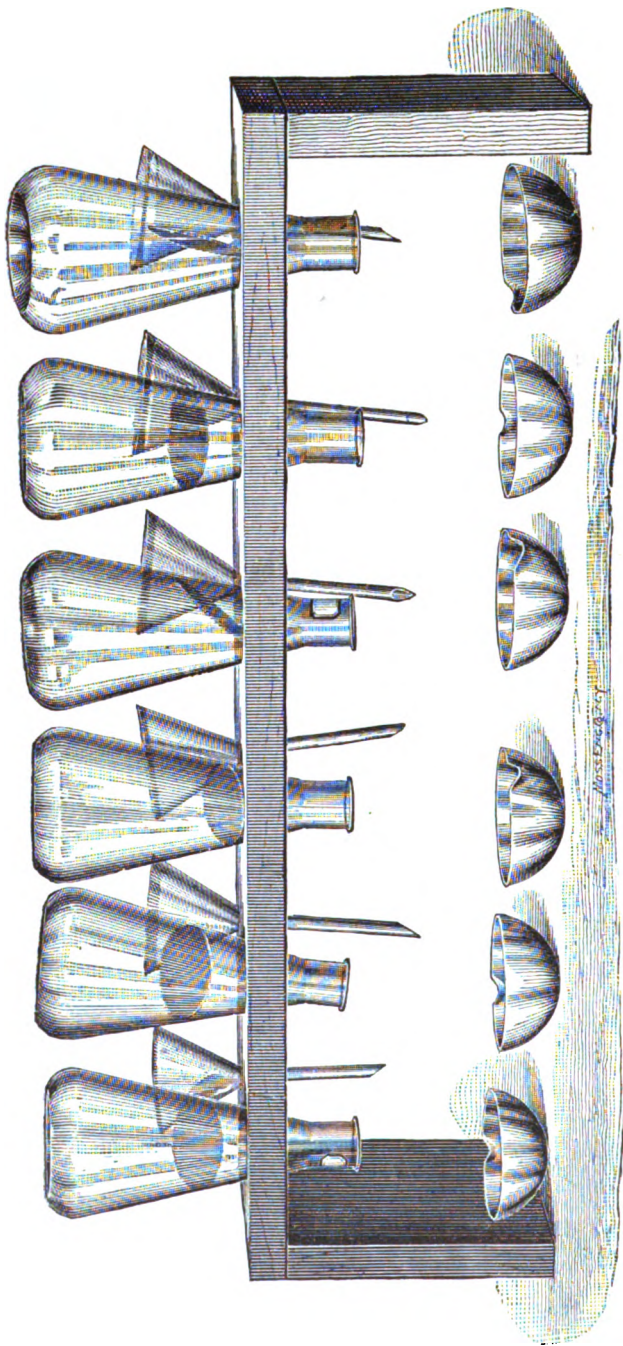


FIG. 3.

break the cake. Two hundred to three hundred cubic centimeters of hot water is next poured on the contents of the flask, the cork with its condenser tube reinserted, and heated on the steam bath until the cake of acids is thoroughly melted, the flask being occasionally agitated with a circular motion, so that none of its contents are brought on the cork. When the fatty acids have again separated as an oily layer, the flask and its contents are cooled in ice water, and the liquid filtered through the same filter into the same liter flask. This treatment with hot water, followed by cooling and filtration of the wash water, is repeated three times, the washings being added to the first filtrate. The mixed washings and filtrate are next made up to 1 liter and 100 cc., in duplicate, is taken and titrated with decinormal NaOH. The volume required is calculated to the whole liquid. The number so obtained represents the measure of decinormal NaOH neutralized by the soluble fatty acids of the butter fat taken, plus that corresponding to the excess of the standard acid used, viz, 1 cc. The amount of soda employed for the neutralization is to be diminished, for the 1 liter, by 5 cc., corresponding to the excess of 1 cc. $\frac{1}{4}$ N. acid.

This corrected volume, multiplied by the factor 0.0088, gives the butyric acid in the weight of butter fat employed. (See table.)

The flask containing the cake of insoluble fat acids is inverted and allowed to drain and dry for twelve hours (Fig. 3), together with the filter paper through which its soluble fatty acids have been filtered. When dry the cake is broken up and transferred to a weighed glass evaporating dish. Remove from the dried filter paper as much of the adhering fat acids as possible and add them to the contents of the dish. The funnel, with the filter paper, is then placed in an Erlenmeyer flask, a hole is made in the bottom of the filter paper, and it is thoroughly washed with absolute alcohol from a wash-bottle. The flask is rinsed with the washings from the filter paper and pure alcohol, and these transferred to the evaporating dish. The dish is placed on the steam bath and the alcohol driven off. It is then transferred to the air bath and dried at 100° C. for two hours, taken out, cooled in a desiccator, and weighed. It is then again placed in the air bath and dried for another two hours, cooled as before, and weighed. If there is no considerable decrease in weight the first weight will do; otherwise, reheat two hours and weigh. This gives the weight of insoluble fat acids in the quantity taken, from which the percentage is easily calculated.

Table for the calculation of soluble fatty acids.

No. cc. KOH sol.	Equiv.	N 10 NaOH.	Equiv.	N 10 NaOH.	Equiv.	N 10 NaOH.	Equiv.
	<i>Grams.</i>		<i>Grams.</i>		<i>Grams.</i>		<i>Grams.</i>
10	.088	+.25	.0802	+.50	.0824	+.75	.0846
11	.0968	25	.0990	50	.1012	75	.1034
12	.1056	25	.1078	50	.1100	75	.1122
13	.1144	25	.1166	50	.1188	75	.1210
14	.1232	25	.1254	50	.1276	75	.1298
15	.1320	25	.1342	50	.1364	75	.1386
16	.1408	25	.1430	50	.1452	75	.1474
17	.1496	25	.1518	50	.1540	75	.1562
18	.1584	25	.1606	50	.1628	75	.1650
19	.1672	25	.1694	50	.1716	75	.1738
20	.1760	25	.1782	50	.1804	75	.1826
21	.1848	25	.1870	50	.1892	75	.1914
22	.1936	25	.1958	50	.1980	75	.2002
23	.2024	25	.2046	50	.2068	75	.2090
24	.2112	25	.2134	50	.2156	75	.2178
25	.2200	25	.2222	50	.2244	75	.2266
26	.2288	25	.2310	50	.2332	75	.2354
27	.2376	25	.2398	50	.2420	75	.2442
28	.2464	25	.2486	50	.2508	75	.2530
29	.2552	25	.2574	50	.2596	75	.2618
30	.2640	25	.2662	50	.2684	75	.2706

The table gives the weight of soluble fatty acids (butyric, &c.) for each quarter of a cubic centimeter of decinormal alkali from 10 to 30.

Example : Weight fat taken	grams..	4.967
No. cc. $\frac{N}{10}$ alkali used		25.50
Less 5 cc. due to 1 cc. $\frac{N}{2}$ acid		20.50
Weight soluble fat acids		1.804
Per cent. soluble fat acids		3.63

SAPONIFICATION EQUIVALENT.

About 2.5 grams butter fat (filtered and free from water) are weighed into a patent rubber-stoppered bottle and 25 cc. approximately semi-normal alcoholic potash added. The exact amount taken is determined by weighing a small pipette with the beaker of fat, running the fat into the bottle from the pipette and weighing beaker and pipette again. The alcoholic potash is measured always in the same pipette, and uniformity further insured by always allowing it to drain the same length of time (thirty seconds). The bottle is then placed in the steam bath together with a blank, containing no fat. After saponification is complete, and the bottles cooled, the contents are titrated with accurately semi-normal hydrochloric acid, using phenol-phthalein as an indicator. The number of cubic centimeters of the acid used for the sample deducted from the number required for the blank gives the number of cubic centimeters which combines with the fat, and the saponification equivalent is calculated by the following formula, in which W equals the weight of fat taken in milligrams and N the number of cubic centimeters which has combined with the fat.

$$\text{Sap. Equiv.} = \frac{2W}{N}$$

If it is desirable to express the number of milligrams of potash for each gram of fat employed it can be done by dividing 5,610 by the saponification equivalent and multiplying the quotient by ten.

WATER.

Place about 2 grams in flat-bottomed platinum dish two-thirds full of clean, dry sand and heat for two hours in air bath at 105° C. (For alternate method of estimation of water see page 73.)

ESTIMATION OF SALT.

Volumetric method.—The amount of the butter or butter substitute to be taken is 5–10 grams; weigh in a counterpoised beaker-glass. The butter (fresh from the refrigerator) is placed in portions of about 1 gram at a time in the beaker, these portions being taken from different parts of the sample. By this means a reasonably fair sample of the whole is obtained.

The given quantity having been weighed out, it is removed from the pan.

Hot water is now added (about 20 cc.) to the beaker, continuing the butter, and after it has melted the liquid is poured into the bulb of the separating apparatus (Fig. 4). The stopper is now inserted and the contents shaken for a few moments.

After standing until the fat has all collected on top of the water, the stop-cock is opened and the water, containing most of the salt, is allowed to run into an Erlenmeyer flask, being careful to let none of the fat globules pass.

Hot water is again added to the beaker and thence poured into the separatory apparatus, the bottle well shaken, and the foregoing process is repeated ten to fifteen times, using each time 10–20 cc. water.

The resulting washings contain all but a mere trace of the NaCl, originally present in the butter.

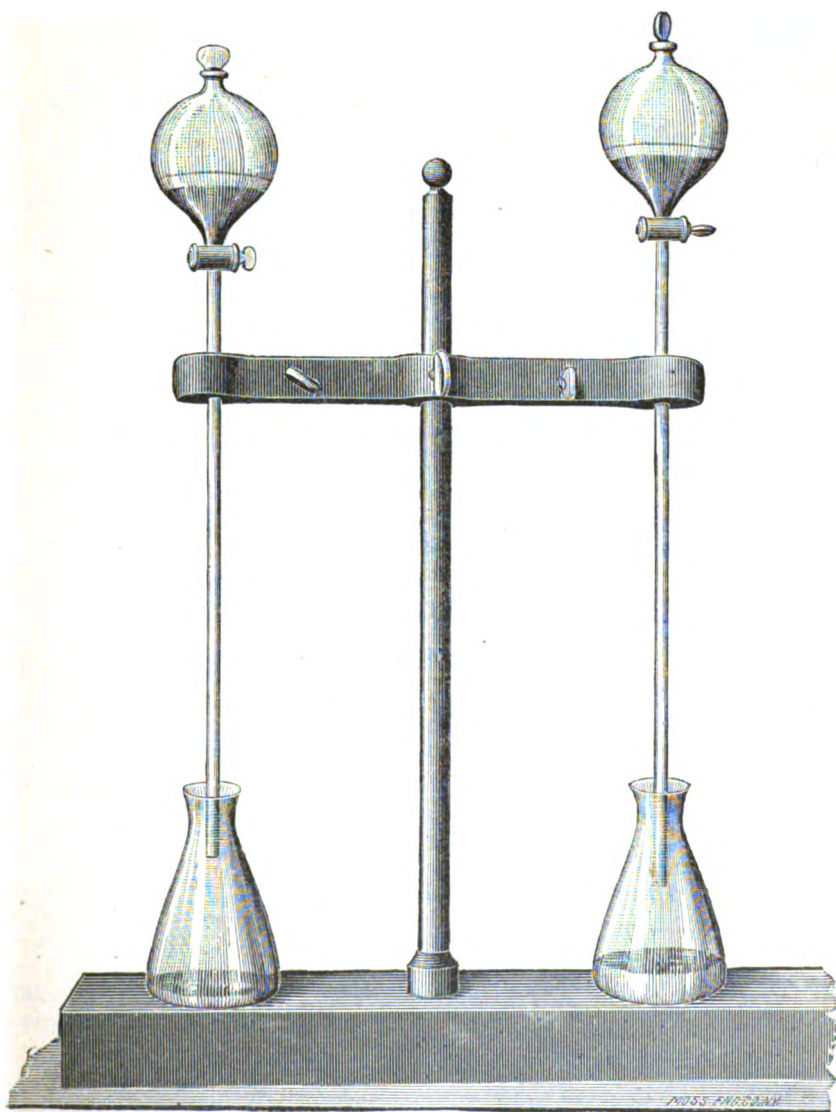


FIG. 4.

Estimation of NaCl in filtrate.—The chloride of sodium is now determined in the filtrate by a standard solution of AgNO_3 , using a few drops of a saturated solution of potassium chromate as indicator.

TOTAL MINERAL MATTER (ASH) AND CURD.

The methods of estimating curd depend on the principle of first drying a weighed portion of the butter, and afterwards extracting the fat with ether or petroleum. The residual mass is then weighed and the curd determined by loss on ignition. This process is carried on as follows:

Five to ten grams of butter are dried at 100°C ., for a few hours in a porcelain dish. The dried fat, &c., is filtered through a Gooch crucible, the contents of the dish all brought into the crucible and well washed with ether or light petroleum. The filter crucible is dried for two hours in air bath and weighed. The curd is then determined by loss of weight on ignition.

The total mineral matter is represented by the residue left after ignition.

Curd and insoluble substances may be estimated somewhat more accurately as follows:

Place the butter (5–10 grams) in a Gooch crucible; set the crucible on a pad of blotting-paper in an air bath (100°C .) for an hour, wash two or three times with ether or light petroleum. Dissolve the salt with hot water, dry at 100°C . and weigh. Any insoluble mineral matter and the ash of the curd is weighed with it in this method.

CASEIN.

Method of Babcock.—Ten grams of the dried butter are treated with light petroleum until all fat is removed. The residue is then ignited with soda-lime or treated by the Kjeldahl method.

METHODS OF MILK ANALYSIS.

ESTIMATION OF WATER.

From a weighing bottle take 5 cc. milk, put in a weighed thin glass dish, or dish lined with tinfoil, one-third full of powdered asbestos; dry for two hours at 100°C . The temperature obtained in a boiling-water bath does not reach 100°C . The milk should be dried in an air bath, the temperature of which is carefully controlled.

ALTERNATE METHOD OF ESTIMATING WATER.

Evaporate one to two grams of milk in shallow watch glass or platinum dish on the water bath for thirty minutes. Dry for an hour at 100°C . and weigh.

ESTIMATION OF CASEIN.

Take 5 grams of milk, digest in Kjeldahl apparatus, with 20 cc. H_2SO_4 , and estimate ammonia in the usual way.

ALTERNATE METHOD OF ESTIMATION OF CASEIN.

Rub up in a mortar the thin dish containing the dried residue from the above process or remove the foil containing it, and transfer to soda-lime combustion tube in the usual way.

The mortar and pestle must be well cleaned with the soda-lime and these cleanings placed in the tube.

Or the dish or tinfoil and its contents may be transferred to a digestion flask and the casein estimated by the method of Kjeldahl.

ESTIMATION OF FAT.

Method of Adams.—The kind of paper and the method of using it first proposed by Adams are as follows:

"As for material, the only extra article is some stout white blotting-paper, known in the trade as 'white demy blotting mill 428,' weighing 38 pounds per ream. This should be in unfolded sheets, machine-cut into strips $2\frac{1}{4}$ inches wide and 22 inches long; each sheet in this manner cuts into seven strips.

"I have tried other papers, but none have answered so well as this; it is very porous and just thick enough. Each of these strips is carefully rolled into a helical coil, for which purpose I use a little machine, made by myself, consisting of a stout double wire, cranked twice at right angles, and mounted in a simple frame. One end of the strip being thrust between the two wires, the handle is turned, and the coil made with great facility. This may be done, for the nonce, on a glass rod, the size of a cedar pencil. Two points have to be carefully attended to: the paper must not be broken, and the coil must be somewhat loose, the finished diameter being a little under an inch. I am in the habit of rolling up a considerable number at a time and placing each within a brass ring as it is rolled, inscribing on one corner with a lead-pencil its own proper number.

"These coils are next thoroughly dried, and I need hardly say the accuracy of the process depends upon this drying. This can be satisfactorily done in an ordinary air bath at 100°C ., providing the bath be heated properly and the paper kept in it long enough. I found the common way of heating the thin bottom of the bath with a single jet not to answer. My bath is placed upon a stout iron surface, which is heated by a large ring of jets; in this way the heat is evenly distributed over the whole of the bottom of the bath, and the papers, which are put in a cage frame of tinned iron wire 5 by $2\frac{1}{4}$ inches and divided into eight partitions, get evenly and completely dried, if allowed to remain in the bath all night, and weighed in a weighing tube next morning, and their weights having been registered according to their numbers, stored away ready for use, as follows:

"The milk to be examined is shaken, and with a pipette 5 cc. are discharged into a small beaker 2 inches high by $1\frac{1}{4}$ diameter, of a capacity of about 30 cc. weighing about 12 grams. This charged beaker is first weighed, and then a paper coil gently thrust into the milk very nearly to the bottom. In a few minutes the paper sucks up nearly the whole of the milk. The paper is then carefully withdrawn by the dry extremity of the coil and gently reversed, and stood, dry end downwards, on a clean sheet of glass. With a little dexterity all but the last fraction of a drop can be removed from the beaker and got on the paper. The beaker is again weighed, and the milk taken got by difference. It is of importance to take up the whole of the milk from the beaker, as I am disposed to consider the paper has a selective action, removing the watery constituents of the milk by preference over the fat.

"The charged paper is next placed in the water oven on the glass plate milk-end upwards, and rough-dried. Mismanagement may possibly cause a drop to pass down through the coil onto the glass. This accident ought never to occur; but if it does, it is revealed in a moment by inspection of the surface of the glass, and the experiment is thereby lost.

"In about an hour it is rough-dried and in a suitable condition for the extraction of the fat."

The method of Adams has been thoroughly tried by the English chemists, and has received the approval of the English Society of Public Analysts. It gives uniformly about .2 per cent. more fat in normal milk than the ordinary gravimetric methods.

The following modification of the process may be used:

"The blotting-paper is replaced by thick filtering paper cut into strips 2 feet long and 2.5 inches wide. These are thoroughly extracted by ether or petroleum ether (or alcohol).

"One end of the strip of paper being held horizontally by a clamp or by an assistant, 5 cc. milk is run out by a pipette from a weighing bottle along the middle of the strip of filtering paper, being careful not to let the milk get too near the ends of the paper, and to secure an even distribution of it over the whole length of the slip. The pipette is replaced in the weighing bottle and the whole reweighed, and thus the quantity of milk taken is accurately determined. The strip of paper is now hung up over a sand bath in an inclosed space high enough to receive it where the air has a temperature of 100° C. (*circa*). In two or three minutes the paper is thoroughly dry. It is at once, while still hot, rolled into a coil and placed, before cooling, in the extraction apparatus already described.

"The fat is dissolved by ether or petroleum, collected in a weighed flask, and, after thorough drying, weighed."

The fat after extraction may also be estimated volumetrically, as described in the method of Morse.

From data which have been collected it appears that the estimation of the fat in milk by the lactocrite is strictly comparable with the results of the Adams method. Those who have this instrument, therefore, can use it instead of the method given.

ALTERNATE METHOD OF ESTIMATING THE FAT IN MILK.

Method of Morse, Piggot, and Burton.—This method consists in the dehydration of the milk by means of anhydrous sulphate of copper; the extraction of the fat by means of the low-boiling products of petroleum; the saponification of the butter by means of an excess of a standard solution of potassium hydroxide in alcohol; and the determination of the excess of the alkali by means of a solution of hydrochloric acid. The following apparatus and reagents are required:

- (1) A porcelain mortar and pestle.
- (2) An extraction tube, 14 or 15 mm. in diameter, 220 mm. in length, with funnel-shaped top. A straight chloride of calcium tube may be used for this.
- (3) A 200 cc. Erlenmeyer flask, strong enough to be used with a filter pump.
- (4) A suitable stand for holding the flask and extraction tube.
- (5) Ten-cubic centimeter pipettes.
- (6) Weighing-glasses with ground-glass stoppers.
- (7) A low-boiling gasoline, distilling between 30° and 60°.
- (8) Dehydrated sulphate of copper.
- (9) Semi-normal solution of potash in 95 per cent. alcohol.
- (10) A semi-normal solution of hydrochloric acid.

Manipulation.—Place about 20 grams of the anhydrous copper sulphate, roughly measured in a copper spoon of the size to hold about that amount, in a porcelain mortar; make a cavity in the center of the mass with the pestle. Allow 10 cc. of the milk to run on to the copper sulphate, being careful that none of it touches the sides of the mortar. When the milk is nearly dry, grind the mass up with a little clean sand, transfer to the extraction tube, gently pressing it down in the tube by means of a glass rod. The lower portion of the extraction tube to be packed with clean cotton wool. The fat is extracted in the following way: 15 cc. of benzine are poured over the material in the extraction tube and drawn down with the aid of the filter pump, until the whole of the mass to be extracted has become wet with the liquid, when the connection with the pump is closed; after about five minutes another portion of 15 cc. of benzine is poured into the tube and the whole of the liquid slowly drawn through with aid of the pump into the flask. Usually one extraction of this kind is sufficient to withdraw the whole of the butter, but for the sake of greater accuracy the process may be repeated two or three times.

Titration.—The benzine may be evaporated and the residual butter fat saponified with about 25 cc. of the approximately semi-normal potash. The residual alkali is determined by means of the semi-normal hydrochloric acid, using phenol-phthalein as indicator. The difference between the amount required in this process and the amount necessary to neutralize the quantity of alkali taken gives the amount of alkali required for the saponification. The number of milligrams of potash required for one gram of the fat is taken at 230. The fat may also be accurately titrated without evaporating the benzine.

ALTERNATE METHOD OF ESTIMATING WATER AND FAT IN MILK.

Method of Babcock.—In the bottom of a perforated test tube is placed a clump of clean cotton; the tube is then filled three-quarters full of ignited asbestos, lightly packed, and a plug of cotton inserted over it. The tube and contents are weighed and the plug of cotton carefully removed and 5 grams of milk from a weighed pipette run into it, and the plug of cotton replaced. The tube connected at its lower end by a rubber tube and adapter with a filter pump is placed in a drying oven of a 100° C., and a slow current of dry air drawn through it until the water is completely expelled which in no case requires more than two hours.

The tube containing the solids from the above operation is placed in an extraction apparatus and exhausted with ether in the usual way.

ALTERNATE METHOD OF ESTIMATING WATER AND FAT.

Method of Professor Macfarlane.—A glass tube 4–5 cc. in length and 2 cm. in diameter, open at one end, drawn out to a tube 5 mm. in diameter at the other end, is two-thirds filled with asbestos fiber, such as is used in manufacturing packing. It is dried in the water bath for several hours, cooled in the desiccator, and weighed. Ten cubic centimeters of the milk is then added from a pipette, which is completely absorbed by the asbestos. It is then weighed, the additional weight of the milk representing the amount taken. The tube, along with many others, is placed in a water bath with constant level and dried for ten or twelve hours (during the night) at a temperature of 90°. Next morning the tubes are cooled in the desiccator and weighed, the loss in weight being the moisture. The tubes are then placed in the Soxhlet extraction apparatus and exhausted with petroleum ether for four hours. They are then removed and dried in a steam bath, cooled in desiccator, and weighed. The loss represents the butter fat.

THE ESTIMATION OF SUGAR.

The reagents, apparatus, and manipulation necessary to give the most reliable results in milk sugar estimation are as follows:

Reagents.—(1) *Basic plumbic acetate*, specific gravity 1.97. Boil a saturated solution of sugar of lead with an excess of litharge, and make it of the strength indicated above. One cubic centimeter of this will precipitate the albumens in 50 to 60 cc. of milk.

(2) *Acid mercuric nitrate*. Dissolve mercury in double its weight of nitric acid, specific gravity 1.42. Add to the solution an equal volume of water. One cubic centimeter of this reagent is sufficient for the quantity of milk mentioned above. Larger quantities can be used without affecting the results of polarization.

(3) *Mercuric iodide with acetic acid*. KI 33.2 grams, HgCl₂ 13.5 grams, H, C₂H₃O 20 cc., H₂O 64 cc.

Apparatus.—(1) Pipettes marked at 59.5, 60, and 60.5 cc. (2) Sugar flasks marked at 102.4 cc. (3) Filters, observation tubes, and polariscope. (4) Specific gravity spindle and cylinder. (5) Thermometers.

Manipulation.—(1) The room and milk should be kept at a constant temperature. It is not important that the temperature should be any given degree. The work can be carried on equally well at 15° C., 20° C., or 25° C. The slight variations in

rotatory power within the above limits will not affect the result for analytical purposes. The temperature selected should be the one which is most easily kept constant.

(2) The specific gravity of the milk is determined. For general work this is done by a delicate specific gravity spindle. Where greater accuracy is required use specific gravity flask.

(3) If the specific gravity be 1.026, or nearly so, measure out 60.5 cc. into the sugar flask. Add 1 cc. of mercuric nitrate solution or 30 cc. mercuric iodide solution and fill to 100.4 cc. mark. The precipitated albumen occupies a volume of about 2.44 cc. Hence the milk solution is really 100 cc. If the specific gravity is 1.030 use 60 cc. of milk. If specific gravity is 1.034 use 59.5 cc. of milk.

(4) Fill up to mark in 102.4 cc. flask, shake well, filter, and polarize.

NOTES.—In the above method of analysis the specific rotatory power of milk sugar is taken at 52.5, and the weight of it in 100 cc. solution to read 100 degrees in the cane sugar scale at 20.56 grams. This is for instruments requiring 16.19 grams sucrose to produce a rotation of 100 sugar degrees. It will be easy to calculate the number for milk sugar whatever instrument is employed.

Since the quality of milk taken is three times 20.56 grams, the polariscopic readings divided by 3 give at once the percentage of milk sugar when a 200 mm. tube is used.

If a 400 mm. tube is employed, divide reading by 6; if a 500 mm. tube is used, divide by 7.5.

Since it requires but little more time, it is advisable to make the analysis in duplicate, and take four readings for each tube. By following this method gross errors or observation are detected and avoided.

By using a flask graduated at 102.4 for 60 cc. no correction for volume of precipitated caseine need be made. In no case is it necessary to heat the sample before polarizing.

In the above method no account is taken of the fat which is retained on the filter with the caseine. It is worth while to inquire if a correction similar to that made for the albuminoids should not also be made for the fat?

ESTIMATION OF ASH.

Evaporate to dryness in a weighed platinum dish 20 cc. of milk from a weighing bottle, to which 6 cc. of HNO_3 has been added, and burn in muffle at low red heat until ash is free from carbon.

APPENDIX B.

OFFICERS AND COMMITTEES OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS OF THE UNITED STATES FOR 1887-1888.

PRESIDENT,

P. E. CHAZAL, State Chemist of South Carolina.

VICE-PRESIDENT,

W. J. GASCOYNE, State Chemist of Virginia.

SECRETARY,

CLIFFORD RICHARDSON, Chemist to the District of Columbia and Honorary Assistant Chemist U. S. Department of Agriculture.

EXECUTIVE COMMITTEE,

E. H. JENKINS, Connecticut Agricultural Experiment Station.

J. A. MYERS, State Chemist of Mississippi.

COMMITTEE ON PHOSPHORIC ACID.

W. J. Gascoyne, of Virginia.
N. W. Lord, of Ohio.
W. E. Moses, of Tennessee.

COMMITTEE ON POTASH.

John A. Myers, of Missouri.
Wm. Frear, of Pennsylvania.
E. H. Jenkins, of Connecticut.

COMMITTEE ON NITROGEN.

M. A. Scovell, of Kentucky.
N. T. Lupton, of Alabama.
Wm. McMurtrie, of Illinois.

COMMITTEE ON CATTLE FOODS.

G. C. Caldwell, of New York.
W. H. Jordan, of Maine.
Clifford Richardson, of District of Columbia.

COMMITTEE ON DAIRY PRODUCTS.

H. W. Wiley, of District of Columbia.
S. M. Babcock, of New York.
H. P. Armsby, of Pennsylvania.

COMMITTEE ON FERMENTED LIQUORS.

W. B. Rising, of California.
C. A. Crampton, of District of Columbia.
G. F. Fellows, of Maryland.

COMMITTEE ON SUGAR.

W. C. Stubbs, of Louisiana.
N. T. Lupton, of Alabama.
H. W. Wiley, of District of Columbia.

APPENDIX C.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This Association shall be known as the Association of Official Agricultural Chemists in the United States. The objects shall be (1) to secure uniformity and accuracy in the methods, results, and modes of statements of analysis of fertilizers, soils, cattle-foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the U. S. Department of Agriculture, or with any State or national agricultural experiment station, or agricultural college or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership, and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to a vote in the Association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the Association by presenting proper credentials and signing this constitution. All analytical chemists and others interested in the objects of the Association may attend its meetings and take part in its discussions, but shall have no vote in the Association.

(3) The officers of the Association shall consist of a president, vice-president, and secretary, who shall also officiate as treasurer; and these officers, together with two other members to be elected by the Association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board, whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee to continue in office till the annual meeting next following.

(4) There shall be appointed by the chair, at the regular annual meeting, standing committees of three members each, to be called, respectively, the Committee on Phosphoric acid, the Committee on Potash, the Committee on Nitrogen, the Committee on Cattle-foods, and the Committee on Dairy Products, whose reports shall be taken up, discussed, and disposed of in the order named. Additional committees may be appointed from time to time as the Association may direct. It shall be the duty of these committees to test methods, to distribute samples to members of the Association and others who may signify their desire to participate in the work, and to present a written report at each annual meeting embodying the progress made during the year in analytical methods bearing on their respective topics, and the results of work done under their direction.

(5) The special duties of the officers of the Association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this Association shall be held at such place as shall be decided by the Association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(8) The executive committee shall confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the Association.

(9) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by a vote of two-thirds of the members present and entitled to vote.



58 From A. A. Proger
U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 17.

RECORD OF EXPERIMENTS

CONDUCTED BY THE

COMMISSIONER OF AGRICULTURE

IN THE

MANUFACTURE OF SUGAR

FROM

SORGHUM AND SUGAR CANES

AT

FORT SCOTT, KANSAS, RIO GRANDE, NEW JERSEY,
AND LAWRENCE, LOUISIANA.

1887-1888.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1888.

Compliments of

Norman J. Colman,

Editor of *Journal of Agriculture*

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 17.

RECO^T

PERIMENTS

CONDUCTED BY THE

COMMISSIONER OF AGRICULTURE

IN THE

MANUFACTURE OF SUGAR

FROM

SORGHUM AND SUGAR CANES

AT

FORT SCOTT, KANSAS, RIO GRANDE, NEW JERSEY,
AND LAWRENCE, LOUISIANA.

1887-1888.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1888.

15449—No. 17

INTRODUCTORY LETTER.

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., January 26, 1888.

SIR: Complying with your instructions I beg to submit herewith for your approval Bulletin No. 17 of the Division of Chemistry, containing a record of the experiments made by your direction in the manufacture of sugar from sorghum and sugar canes.

The bulletin is divided into three parts, viz:

PART I, *experiments with sorghum at Fort Scott*.—Containing the report of M. Swenson; drawings and description of apparatus; a digest of the report of E. B. Cowgill to the State board of agriculture at Topeka, Kans.; and a statement of the action taken by the Department in respect of certain letters patent granted to M. Swenson for the use of lime carbonates in the cells of the battery.

PART II, *experiments at Rio Grande*.—Containing the report of H. A. Hughes, drawings and description of apparatus used, and analytical notes.

PART III, *experiments in Louisiana*.—Containing the report of H. W. Wiley of the results of the experiments conducted at Lawrence, La.

In obedience to your further orders, I took charge of the chemical work of the three stations. During the summer of 1887 the necessary apparatus and chemicals were purchased and sent to the several stations. Of my assistants, C. A. Crampton and N. J. Fake were directed to take charge of the analytical work at Fort Scott, and were furnished with written instructions for their guidance in taking samples and the general method of analyses to be followed.

F. V. Broadbent and H. Edson were sent to Rio Grande. They had the same instructions as were given my assistants at Fort Scott. In addition to this I personally directed the beginning of their work. On October 14, 1887, Mr. Broadbent resigned his position in the Department for the purpose of pursuing his studies abroad. Mr. Edson from that date had sole charge of the analytical work until the end of the season.

On April 2, 1887, G. L. Spencer was sent to Fort Scott to secure the removal of certain machinery to Lawrence and joined Mr. Barthelemy in the work of preparation at that station.

At the close of the work at Fort Scott, Dr. Crampton and Mr. Fake also came to Lawrence to assist in the chemical work at that place.

In the following pages only such chemical data are given as are necessary to illustrate the experiments made. Much of the chemical work is yet undone, and it would delay too long the publishing of this bulletin to wait for its completion. All the details of the chemical work for all three stations will therefore be collected and published in a separate bulletin, viz, No. 18. The success of the work at all three stations has been most gratifying, and the diffusion process for the manufacture of sugar has been advanced beyond the experimental stage by the labors of this Department, beginning in 1883, and it is now offered to the sugar-growers of the country with the confident assurance that it is the best, most simple, and most economical method of extracting sugar both from sorghum and sugar canes.

Respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner.

PART I.

EXPERIMENTS WITH SORGHUM AT FORT SCOTT.

LETTER OF TRANSMITTAL.

FORT SCOTT, KANS., November 9, 1887.

SIR: I herewith submit my report of the experiments in the manufacture of sugar from sorghum cane, conducted at Fort Scott, Kans., during the present year.

I beg to acknowledge my appreciation of the hearty support that you have accorded me while in charge of this work.

Very respectfully,

MAGNUS SWENSON.

Hon. NORMAN J. COLMAN,

Commissioner of Agriculture, Washington, D. C.

REPORT OF M. SWENSON.

Previous to my appointment to take charge of the experiments in the manufacture of sugar from sorghum cane at Fort Scott, Kans., all attempts to make sugar from this source in paying quantities had failed. This was due to many difficulties, of both a mechanical and a chemical nature, in the manipulation of the cane and juice. The most important problems to be solved were the proper cutting and cleaning of the cane, the prevention of inversion of cane sugar in the diffusion battery, and to find a cheap and effective method for treating the diffusion juice.

PRELIMINARY EXPERIMENTS.

As soon as the earliest of the amber cane approached ripeness a large number of preliminary experiments were made in defecation and filtration of juices. The experiments in filtration were made with a small filter press with a hand pump. The cloth used was the same as that used in the large presses, and every precaution was taken to make the results just as valuable as if made on a larger scale. These experiments were begun on July 29. The filtering materials used were finely pow-

dered lignite, bituminous coal, shale, several kinds of soils, and prepared carbonate of lime. The following conclusions were derived from these experiments :

(1) None of the above materials would filter juice satisfactorily that had an acid reaction.

(2) Neutral juice filtered very slowly and a hard-press cake would not form in the press.

(3) With a decidedly alkaline juice the filtration took place much more readily, but was not entirely satisfactory except with carbonate of lime.

(4) Lignite did not have any apparent decolorizing effect on the juice except when the juice had become highly colored by adding an excess of lime, when a slight decolorization took place. A large number of experiments were made with varying quantities of lignite, but in no case did it show any superiority over fine sandy loam, either as a decolorizer or filtering medium.

Experiments for testing the cutting, cleaning, and elevating machinery were also conducted as early as the condition of the cane would permit.

The method of unloading the cane and getting it onto the carrier was similar to that employed last year. The seed heads, however, were cut off in the field. The cutters were made by the Belle City Manufacturing Company, of Racine, Wis. They did the work well, but the machines were too light to stand the very severe work they were called upon to do.

The cane was cut into pieces about an inch long and then elevated by a drag to the top of a series of four fans standing straight over each other, each fan being furnished with a separate set of shakers. The cleaning apparatus, after considerable adjustment, did fairly good work. The leaves and sheaths were removed by a suction fan. The cleaned pieces of cane were cut by a rapidly revolving cutter, consisting of a cylinder carrying thirty knives. The cylinder was made up of three separate sections, each with ten knives. Although no difficulty was encountered in cutting, the work of the cutter was very unsatisfactory. A large portion of the chips consisted of long pieces with the bark on one side. Diffusion in this case could take place but in one direction, and in the largest chips of this kind the extraction of the sugar was very imperfect. The drag for conveying the chips to the cells was rebuilt and placed higher and on one side of the battery so as not to interfere with the packing of the chips in the cells. The exhausted chips were dumped directly into a car running on rails under the battery. This car was run up an incline onto a trestle work about 20 feet from the ground, by the aid of an endless cable. Two friction clutches, running in opposite directions, served to run the car forward or backward, and the car was so arranged that the charge of exhausted chips could be dropped at any point by simply reversing the motion of the cable.

EXPERIMENTS WITH CRUSHER.

It was the opinion of a number of men interested in this industry that a very much larger yield and better quality of juice could be obtained by the crushers if the cane, previously to being pressed, were cleaned and macerated, and it was deemed best to give the matter a thorough trial. For this purpose a 3-foot cane mill was purchased from J. A. Field & Co., of Saint Louis. It consisted of a three-roller mill and a supplemental two-roller mill. The principal trouble encountered was in feeding the mill. Even with an arrangement for forcing the chips between the rolls not over three tons per hour could be forced through, and the yield of juice was but little if any greater than when whole cane was fed to the mill.

The average yield of syrup was about 10 gallons per ton of cane worked. The same kind of cane yielded by diffusion 25 gallons of syrup per ton of cane. The cane used in this trial was very poor, being mostly lodged. These experiments show conclusively the great superiority of the diffusion process for syrup making, a very good quality of sirup being produced from very poor cane. It was superior in both color and flavor to the sirup from the mill juice. The juices from the mill and battery were treated precisely alike and they were skimmed and evaporated in an open steam evaporator. This is a matter of great importance to all engaged in the sugar business, as both at the beginning and close of the season there will be considerable cane that is not fit for sugar-making, and the fact that 25 gallons of first-class sirup can be made from such cane by diffusion makes it possible to work even such material at a good profit.

The first run for sugar was begun on August 26. The juice was made alkaline with lime, and about 2 per cent. of carbonate of lime was added. It was then filtered. To other portions of juice, instead of carbonate of lime, 3 per cent. of ground shale, bituminous coal, and sandy loam were added respectively. The filtrations were very imperfect except with the carbonate of lime and in every way corresponded with the preliminary experiments. Lignite was not used on a large scale because I had at the time no means of grinding it; but judging from a large number of experiments made in the beginning of the season, it is safe to conclude that it would not have filtered any better than the other materials used.

Satisfactory filtrations were only produced when the juice had been made strongly alkaline, and no material was found which would filter the juice when left slightly acid.

On August 30 the first strike was made, and the yield was a little more than 100 pounds of washed sugar per ton of clean cane.

INVERSION OF CANE SUGAR.

To prevent the inversion of the sugar in battery, about 10 pounds of dry precipitated carbonate of lime was mixed with enough water to pro-

duce a thin paste. This was added to the fresh chips while the cell was being filled, and entirely prevented any loss of sugar by inversion.

The carbonate was made by forcing carbonic acid gas by the aid of a pump into thin milk of lime. The injection pipe was perforated and lay along the bottom of a 10 by 10 feet tank containing the milk of lime. The gas was produced by burning coke in a small furnace. When the lime showed but a slight alkaline reaction it was run off into a large hole in the ground where the water soon drained away, leaving the carbonate nearly dry.

EXPERIMENTS WITH DEFECACTION.

On September 1 filtration was dispensed with and experiments tried with simple defecation. The defecators were similar to those in ordinary use, being simply round tanks with conical bottoms and furnished with coils for heating the juice. This method of defecation, however, was not satisfactory, and defecation was tried in a shallow pan 16 feet long and 26 inches wide, with a partition running lengthwise in the center, the inlet and outlet for the juice being on the same end of the pan on opposite sides of the partition.

This pan was gotten up very hurriedly and was supplied with iron pipes for heating the juice. The juice, after being previously limed and somewhat heated, was pumped into one side of the long heating pan and run out at the opposite side continuously:

Being compelled by the center partition to flow down one side and back on the other, the juice made a circuit of 32 feet. The steam was so regulated that during the first 16 feet it was gradually brought to the boiling point, while in the opposite side it boiled vigorously. In this way a strong current was produced which carried all the impurities in the form of scum to the quiet portion of the juice, where it was removed and returned to the battery, thus avoiding all waste and annoyance from this source.

EVAPORATION.

The juice was evaporated to from 20° to 30° Baumé, in a double effect evaporator built by the Pusey & Jones Company, of Wilmington, Del. This apparatus gave perfect satisfaction. All the evaporation was done by exhaust steam of 4 pounds pressure, a small amount of live steam being used only when part of the machinery was stopped.

EXPERIMENTS IN BOILING TO GRAIN.

Every strike was boiled to grain in the pan. Several experiments were made to ascertain the result in boiling "in and in," the juice being enriched by the addition of sugar made from previous strikes. It is very doubtful, however, whether this is to be recommended, excepting when the juice is so poor that a good grain can not be obtained in any other way.

Owing to the fact that we were unable to secure a sufficient supply of cane the work progressed very irregularly. Only twice during the entire season was the battery kept in operation continuously, for twenty hours, and during the sugar-making season the diffusion battery was emptied sixty-two times. This entailed no inconsiderable loss, amounting to from 1 to 2 tons of clean cane each time a stoppage occurred.

CANE WORKED FOR SUGAR.

The total amount of cane worked for sugar was 2,610 tons. In this is included all that was used for experiments in filtration and defecation during the first part of the season. I have no record of the exact amount lost in this way. The total amount of first sugar made was 235,476 pounds. This sugar was all washed, and polarized on an average 96 per cent. The total amount of molasses produced was 51,000 gallons.

TRIAL RUNS.

In order to ascertain as nearly as possible the average yield of sugar per ton of cane two trial runs were made.

FIRST TRIAL.

On September 15 a strike was made from 133 tons of clean cane. In order to obtain a better grain 2,600 pounds of sugar was added to the juice after it had been defecated; 2,200 pounds of juice were drawn from each cell.

The following is a record of this experiment:

Sucrose in mill, juice from chips.....	10.00
Glucose in mill, juice from chips.....	3.41
Solids not sugar, juice from chips.....	3.20
Ratio of sucrose to glucose.....	2.94
Coefficient of purity.....	60.3
Sucrose in diffusion juice.....	7.91
Glucose in diffusion juice.....	2.60
Solids not sugar, diffusion juice.....	2.59
Ratio of sucrose to glucose.....	3.04
Coefficient of purity.....	60.4
Sucrose in defecated juice.....	8.34
Glucose in defecated juice.....	2.40
Solids not sugar, defecated juice.....	2.46
Ratio of sucrose to glucose.....	3.47
Coefficient of purity.....	63.6
Total weight of first sugar..... pounds..	17,608
Sugar added to juice..... do.....	2,600
Total yield first sugar..... do.....	15,008
Total yield of second sugar..... do.....	2,330
Total yield of molasses..... gallons..	2,220

Yield per ton :

First sugar	pounds..	113.00
Second sugar	do	17.5
Molasses	gallons..	15.5
First sugar polarized		93.0
Second sugar polarized		88.7

Temperature in battery was between 75° and 80° C.

SECOND TRIAL.

Eighty-six tons of clean cane were worked; 54 tons on October 1, and 32 tons on October 2. All was boiled in one strike. No analyses were made on October 2, and unfortunately the complete data can not therefore be given. The juice was not enriched as in the previous trial.

The following are the results:

Yield of first sugar	pounds..	9,292
Yield of second sugar	do	1,988
Yield of molasses	gallons..	1,462
Yield per ton :		
First sugar	pounds..	108
Second sugar	do	23
Molasses	gallons..	17
First sugar polarized		97
Second sugar polarized		88

AVERAGE YIELD OF SUGAR.

Making a fair allowance for cane and juice lost in experiments during the first part of the season, the average yield of first sugars will be fully 100 pounds per ton, polarizing 97. A strike of average molasses boiled to string proof yielded 12½ per cent. of the weight of the *masse cuite* in sugar, containing 88 per cent. of sucrose. This is at the rate of 28 pounds per ton of cane. Had the entire crop been boiled for seconds the average yield per ton of cane would not have been less than 128 pounds of sugar and 16 gallons of molasses. From a financial standpoint the advantage of working for seconds depends entirely on the sirup market. In my judgment it would not have paid this season, as the market is better than for years past. The entire product of 51,000 gallons has already been sold at a good price.

AVAILABLE SUGAR.

It is at once apparent that the old method of calculating available sugar must be abandoned. According to this rule there would be but 61.6 pounds available sugar per ton of cane in the diffusion juice of the first trial, when as a matter of fact 130½ pounds was obtained. It would therefore seem that instead of preventing an equal weight of cane sugar from crystallizing, the glucose and other solids not sugar in the juice prevented only two-fifths of their weight of cane sugar from crystallizing. This is also borne out by the data furnished by the analysis of the juices during the entire season.

Average analyses from tables prepared by Dr. Crampton.

For week ending.	Mill juices.			Diffusion juices.			Total sugar (exhaust chips).
	Brix.	Sucrose.	Glucose.	Brix.	Sucrose.	Glucose.	
September 17.....	16.9	9.99	3.46	12.8	7.71	2.28	.99
September 24.....	17.3	9.63	3.52	12.2	6.88	2.35	.96
October 1.....	16.4	9.44	3.24	10.9	6.34	2.21	.93
October 9.....	16.4	9.96	3.38	11.0	6.60	2.31	.98
October 16.....	14.8	9.34	2.98	10.1	6.38	1.90	1.10
Average for season....	16.3	9.67	3.31	11.4	6.79	2.21	.93

Average ratio of sucrose to glucose in mill juices.....	2.92
Average coefficient of purity of mill juices.....	59.3
Average ratio of sucrose to glucose in diffusion juices.....	3.07
Average coefficient of purity of diffusion juices.....	59.5

The above table discloses two very important facts :

(1) The very uniform condition of the cane throughout the entire season.

(2) By the use of a small quantity of carbonate of lime in the cells the inversion of cane sugar is entirely prevented.

The amount of sugar left in the chips is larger than it ought to be. This is due, as previously stated, to the bad shape of some of the chips. For this reason the juice was also more dilute, as larger charges had to be drawn in order to get a more complete extraction. Up to September 22 the amount drawn was 2,200 pounds. From this to October 4 2,640 pounds, and from October 4 to the end of the season 2,420 pounds were drawn.

The temperature of the battery was maintained near 80°C.

EFFECT OF HEAT.

In order to determine the amount of inversion taking place when the juice was evaporated to sirup, in an open pan, the following experiments were made. Juice was boiled down in the open pan used for defecating, and samples taken at different intervals.

The following are the analyses:

Brix.	Sucrose.	Glucose.	Ratio of sucrose to glucose.
13.0	8.08	2.39	3.38
21.7	13.49	3.87	3.48
27.7	33.30	9.50	3.50
	37.20	11.36	3.27
	41.10	lost.	

[Trial on Potter's evaporator.]

Sucrose.	Glucose.	Ratio of sucrose to glucose.
6.71	2.04	3.44
39.20	11.60	3.32
50.00	15.26	3.21
51.00	13.88	3.21

The juice in both cases was made as nearly neutral with lime as possible.

It seems from the above that the invertive action of the heat has been greatly overestimated, and that when the juice is not acid no appreciable inversion takes place even when the juice is reduced to a moderately heavy sirup in an open pan.

From Mr. Parkinson's report it will be seen that the loss in leaves and sheaths amounted to about 11 per cent. of the weight of the topped cane. This loss can no doubt be somewhat reduced when the cleaning machines become better adapted to the work.

According to a number of trials with freshly cut cane the weight of leaves and sheaths amounted to 10 per cent. and the seed tops to 15 per cent. of the weight of the whole plant. Late in the season when the leaves become dry this proportion is of course considerably less.

COST OF A FACTORY.

A very important fact to determine is, the capacity and cost of a factory that will work the cane most economically. There can be no doubt but the advantages are greatly on the side of the large factory. The office expenses and cost of management will be but little, if any, greater. All the machinery required in a large factory is equally necessary in a small one and the proportionate price of this machinery is in favor of the larger factory. In other words, a factory working 200 tons of cane per day will cost much less than double the cost of a factory working 100 tons. Again, the cost of operating a large factory is proportionately much less. It takes no more men to operate a diffusion battery with a capacity of 200 tons of cane than one half as large, and this is true of the larger part of the machinery in the factory. A point may of course be reached where the size of the machinery becomes too large for economical working, and when the amount of cane needed for working will be greater than can be grown within easy reach of the factory.

Judging from our present knowledge, a factory capable of working from 200 to 250 tons of cleaned cane per day seems the most desirable. This would require a diffusion battery of 12 cells, each cell having a capacity of 112 cubic feet. The evaporating apparatus should have a capacity of 250 tons of water per day and a strike pan with a proportionate capacity. The cost of such machinery will, of course, depend largely on its kind and quality, and can be readily obtained from any reliable manufacturer. The cost of a factory is almost always underestimated, owing to many items which are not taken into account. The capital for building a factory of the above capacity should not be less than \$100,000 to \$125,000, any thing below being certainly unsafe. Nothing but the best machinery should be used and every precaution should be taken to prevent breakage of machinery and to be able to

make repairs quickly by having duplicate parts of such machinery as are liable to break. There is no manufacture which depends more for its success on the proper working of the machinery than the sugar industry.

COST OF WORKING.

The success of this industry does not depend altogether on how much sugar can be produced per ton of cane, but the cost of this production must also be considered.

The success of the work during the past season has been largely due to the simplicity and cheapness of the processes employed. For the actual cost of production and other data of the utmost interest to those who contemplate engaging in this industry, I can not do better than refer them to the report of W. L. Parkinson to the board of directors of the Parkinson Sugar Company, which I have the permission to embody in this report.¹

There is no doubt but that \$2 per ton for working cane are sufficient to cover all legitimate expenses connected with the manufacture.

UTILIZATION OF THE EXHAUST CHIPS.

It will soon become a matter of necessity to dispose in some way of the exhausted chips from the battery.

The great amount of this material accumulating about the factory makes it imperative that they be utilized in some way. Three methods of disposition have been suggested: (1) To return them to the land as a fertilizer; (2) to use them for fuel; (3) to manufacture into paper pulp. One of the last two methods will no doubt be adopted. Some experiments in using for fuel were made during the season. A large portion of the water was pressed out by passing the chips through a 3-foot cane-crusher. The chips dropped from the last roll into a hopper, from which they were taken up by a suction-fan and blown over to the boiler-house. This method of handling the chips has many features to recommend it. It is very simple, and, besides, the chips are dried somewhat by being subjected to the strong current of air. No doubt the making of paper pulp from the chips will become the most profitable disposition to make of them. The cane after being reduced to fine chips and thoroughly washed in the diffusion battery is certainly in an excellent condition for this work. No attempts have been made, as far as I know, to make paper pulp on a large scale from this source, but very fine samples of pure white pulp have been made in a small way. This matter is certainly deserving of thorough investigation.

NEEDS OF THE INDUSTRY.

One of the greatest difficulties which will be encountered by those engaged in developing this industry will be the scarcity of men capable of operating factories. This will be the most serious hinderance to rapid

¹ See Cowgill's Report, p. 21.)

development, as nothing but time can produce men of the requisite experience. The establishment of a school for training young men in this work would be of inestimable value. Here they should receive thorough technical training, which should be supplemented with a drill in the factories while they are in operation. This would in a short time develop a number of men capable not only of taking charge of a factory, but also qualified to conduct independent research, which, in so fruitful a field, could not but result in great good to the industry.

The improvement of the sorghum cane is also one of the subjects which should receive immediate attention.

Although very little has been attempted in this line, enough has been done to show that the cane sugar is greatly increased by good culture, and that it is susceptible of very great improvement by the various methods known to scientific agriculture there can be no doubt. The idea that sorghum cane will grow anywhere and do well with any kind of treatment is one of the main causes of poor cane. Instead of receiving thorough culture, it generally gets only such attention as can be spared from the other crops. If the price paid for cane could be regulated by the actual amount of sugar it contained, the farmer would soon find it to his advantage to devote more time to his cane field.

The establishment of a sugar refinery within easy reach of the sorghum-sugar factories will be one of the imperative needs in the near future. The demand for any kind of sugar but white granulated is comparatively limited. The sugar produced at Fort Scott averaged within $2\frac{1}{2}$ per cent. of being as pure as the best granulated, while the selling price has been about $1\frac{1}{2}$ cents per pound less, or a difference of about 25 per cent. The most feasible manner of conducting the refinery, at least in the near future, will be to supply one or more factories with the additional appliances needed, and when the season's work is over the sugar from a number of factories could be refined there during the balance of the year.

Before closing this report I wish to extend my thanks to Mr. W. L. Parkinson, manager of the Parkinson Sugar Company, for his hearty co-operation. The successful handling, cutting, and cleaning the cane were due to the results of his thought and labor.

I also desire to express my appreciation of the faithful and valuable services rendered by my assistants, Messrs. J. C. Hart and J. N. Wilcox; and my thanks are due Dr. C. A. Crampton and Mr. N. J. Fake, chemists of the U. S. Department of Agriculture, for aid and courtesies extended.

CONCLUSIONS.

In reviewing the work the most important point suggested is the complete success of the experiments in demonstrating the commercial practicability of manufacturing sugar from sorghum cane.

(2) That sugar was produced uniformly throughout the entire season.

(3) That this was not due to any extraordinary content of sugar in the cane, but, on the contrary, the cane was much injured by severe drought and chinch-bugs.

(4) That the value of the sugar and molasses obtained this year per ton of sorghum cane will compare favorably with that of the highest yields obtained in Louisiana from sugar-cane, and, taking into consideration the much greater cost of the sugar-cane, and that it has no equivalent to the 2 bushels of seed yielded per ton of sorghum cane, also our much cheaper fuel, I say without hesitancy that sugar can be produced fully as cheaply in Kansas as in Louisiana.

M. SWENSON.

SUMMARY OF CHEMICAL WORK DONE AT FORT SCOTT, 1887.

[Abstract of report of C. A. Crampton.]

Analyses were begun on the 3d of September, but a full chemical control of the work was not established until the 8th.

Samples of the fresh chips, diffusion juices, and exhausted chips were taken in the usual way, great care being taken to have them represent as accurately as possible the mean properties of the several substances mentioned.

TABLE 1.—*Analyses of juices of fresh chips.*

Number of analyses	55
Sucrose :	Per cent
Mean	9.54
Maximum	11.51
Minimum	6.20
Glucose :	
Mean	3.40
Maximum	6.49
Minimum	1.39
Total solids (spindle) :	
Mean	16.14
Maximum	17.18
Minimum	13.09

TABLE 2.—*Diffusion juices.*

Number of analyses	51
Sucrose :	Per cent.
Mean	6.68
Maximum	8.79
Minimum	5.05
Glucose :	
Mean	2.26
Maximum	3.07
Minimum	1.75
Total solids (spindle) :	
Mean	11.08
Maximum	13.10
Minimum	8.64

TABLE 3.—*Exhausted chips.*

Number of analyses	29
Both sugars:	Per cent.
Mean	1.03
Maximum	1.83
Minimum	.49

TABLE 4.—*Clarified juices.*

Number of analyses	25
Sucrose:	Per cent.
Mean	6.91
Maximum	8.25
Minimum	5.11
Glucose:	
Mean	2.19
Maximum	2.85
Minimum	1.69
Total solids (spindle):	
Mean	11.31
Maximum	13.35
Minimum	8.94

TABLE 5.—*Syrups.*

Number of analyses	14
Sucrose:	Per cent.
Mean	29.90
Maximum	41.90
Minimum	16.10
Glucose:	
Mean	10.06
Maximum	16.26
Minimum	7.52
Total solids (spindle):	
Mean	46.02
Maximum	60.40
Minimum	36.20

TABLE 6.—*First sugars.*

Number of analyses	28
Sucrose:	Per cent.
Mean	95.64
Maximum	98.10
Minimum	92.40

TABLE 7.—*Second sugars.*

Number of analyses	3
Sucrose:	Per cent.
Mean	85.80
Maximum	88.70
Minimum	82.30

The analyses of the molasses, masse cuites, and some other products are not yet complete, but will be given in full in Bulletin No. 18.

The ratio of sucrose to glucose in the fresh chips and diffusion juices for the season was as follows:

Mill juice	1 : 2.80
Diffusion juice	1 : 2.95

This would seem to show one of two things, either that there was absolutely no inversion in the battery or that the glucose in the cane was not so readily diffused as the sucrose. The latter hypothesis seems to be borne out by the analyses of the exhausted chips as shown in the following table of analyses:

Sucrose and glucose in juice from exhausted chips and corresponding diffusion juices.

Date.	Exhausted chips.			Diffusion juices.		
	No.	Sucrose.	Glucose.	No.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Oct. 8	248	.78	.57	247	5.90	3.53
Oct. 11	260	.87	.51	259	6.58	2.09
Oct. 12	267	.63	.29	266	6.17	2.03
Oct. 13	280	.95	.48	279	5.97	1.89
Oct. 14	289	.52	.24	288	6.02	1.80
Oct. 15	294	.75	.27	293	5.66	1.75
Oct. 18	313	.99	.43	312	5.66	2.02
Average .....	.....	.78	.40	.....	5.99	2.09

15449—No. 17—2

THE SORGHUM-SUGAR INDUSTRY IN KANSAS.*

REPORT OF E. B. COWGILL.

OFFICE OF THE STATE BOARD OF AGRICULTURE,
Topeka, Kans., December 17, 1887.

While all attempts to manufacture sugar from sorghum in Kansas had, prior to the present season, resulted in disappointment and financial disaster, confidence was not destroyed. The failures of the past, and the obstacles to success, which many of large experience had declared to be insurmountable, seemed only to nerve those whose confidence in the final success of the industry remained unshaken; to renewed and more determined effort. Congress had been induced to provide means to aid in the further prosecution of experimental work, but capital was required to enable Kansas to avail herself of the assistance offered. Those having the greatest financial interest in the industry were generally discouraged, and individuals having nothing at risk could hardly be expected to invest in so unpromising an enterprise.

Under these circumstances the legislature was appealed to, and on March 5, 1887, "an act to encourage the manufacture of sugar" was secured, which provides: First, that a bounty of two cents per pound shall be paid upon all sugar manufactured in this State from beets, sorghum, or other sugar-yielding canes or plants grown in Kansas. Second, that no bounty shall be paid upon sugar containing less than 90 per cent. of crystallized sugar, the quantity and quality to be determined by the secretary of the State board of agriculture, or other person appointed by him, the cost of such inspection to be borne by the claimant. Third, the sum of money so to be paid shall not exceed in any one year \$15,000.

The secretary of the board, recognizing his inability to perform the duties imposed by the act above referred to, did, on the 15th day of August, 1887, by virtue of the authority in him vested, appoint and commission Prof. E. B. Cowgill inspector, under the provisions of said act, and authorized and empowered him to do and perform, all and singular, the duties as such inspector; also to make such observation and

* This report has been corrected by the author, several errors having been overlooked in the advance sheets.

investigation of the means and methods employed in the manufacture of sugar as the public interest might seem to require; and to report to this office, as required by law, and indicated in the instructions transmitted with said commission, as follows:

STATE BOARD OF AGRICULTURE,
Topeka, Kans., August 15, 1887.

DEAR SIR: In inspecting sugar, on which bounty is claimed under the act of the legislature approved March 5, 1887, and in your observations of processes, and in investigating the subject of sugar making in Kansas under the commission herewith presented, you will observe the following instructions:

I. In accordance with section 2 of said act, you will proceed to inspect sugar made in Kansas when called upon by the manufacturers, and,

First, determine the percentage of crystallized sugar, uncrystallized sugar, and of substances not sugar, contained in each package presented for inspection.

Second, keep a full and correct record of the quantities and qualities of sugar on which bounty is claimed.

II. In determining the quality of sugars you will make analyses by the copper reduction, or such other method or methods as you may deem best.

III. You will weigh and brand all sugars inspected, and keep possession of the same until delivered or consigned to purchaser, and you will keep a correct record of each delivery and consignment: *Provided*, That you may permit delivery and shipments to be made, during your absence from the works, by some person to be designated by you, who shall keep a full and correct record of such delivery and consignment, and present to you a sworn statement of the same, together with receipts of purchaser or transportation companies.

IV. You shall also take such sworn testimony of manufacturers, employes, station agents, or consignees, and such other evidence as shall fully determine the quantity of the sugar to be reported for payment of bounty.

V. When the entire product of the season at any factory has been inspected, and your record completed as above directed, you will transmit to this office a sworn statement, showing the quality and quantity of sugars made by said factory, and will turn over to the manufacturers all unsold products.

VI. You will observe processes and experiments, and make investigations as opportunities permit, and report fully to this office, to the end that the people of the State may have the advantage of all information gained and processes developed under the encouragement of the bounty provided in the act above referred to.

Yours truly,

WM. SIMS,
Secretary State Board of Agriculture.

Prof. E. B. COWGILL,
Sterling, Kans.

The appointment above referred to was, on the 21st day of August, 1887, duly accepted by Professor Cowgill, who filed herein his oath of office, and at once entered upon the duties of his said appointment, and who, on the 7th day of December, 1887, delivered to the secretary of the board his report, as such inspector, showing the quantity and quality of sugar contained in each of the packages presented for inspection, and on which bounty was claimed and is now due under the provisions of the act of March 5, 1887, above referred to.

This report shows 842 packages, containing 234,607 pounds of sugar, to have been inspected and branded as provided by law, and that the

packages so inspected contained from 92 to 98 per cent. of crystallized sugar, respectively.

The amount claimed as bounty, and due thereon from the State treasury, is \$4,692.14, leaving of the appropriation for 1887, above referred to, unclaimed, the sum of \$10,307.86.

And afterwards, to wit, on the 15th day of December, 1887, there was filed in this office, by Professor Cowgill, his complete and final report relating to the sorghum-sugar industry in Kansas, which is herewith submitted for the information of the public.

WM. SIMS,
Secretary.

LETTER OF TRANSMITTAL.

SIR: Under commission from your office dated August 15, 1887, and instructions to inspect and brand sugars made in this State during the season of 1887, as provided in the act of the legislature approved March 5, 1887, and under your further instructions to ascertain whether sugar-making in Kansas is a success or a failure, and why, I proceeded to the Parkinson Sugar Works, at Fort Scott, the only sugar factory in operation in the State, and inspected and branded the sugar produced, as set forth in detail in Exhibit A. I also made a careful study of the processes used, and submit herewith my report. I am aware that much that is contained in the following pages is not new to those familiar with the usual methods of making sugar; but realizing that to most of those who will read this report the details of the entire subject are new, I have deemed it proper to describe the old as well as the new in the processes employed in the manufacture as at present conducted. I have not hoped to enable persons unfamiliar with the subject to at once enter upon the profitable manufacture of sugar, but to help those who are studying the subject, and to place reliable information on a most important new industry within the reach of the intelligent Kansas public.

I am, sir, yours respectfully,

E. B. COWGILL.

Hon. WM. SIMS,
Secretary State Board of Agriculture.

REPORT OF E. B. COWGILL.

HISTORICAL SKETCH.

The sorghum plant was introduced into the United States in 1853-'54 by the Patent Office, which then embraced all there was of the United States Department of Agriculture. Its juice was known to be sweet, and chemists were not long in discovering that it contained a considerable percentage of some substance giving the reactions of cane sugar. The opinion that the reactions were due to cane sugar received repeated confirmations in the formation of true cane-sugar crystals in sirups made from sorghum. Yet the small amounts that were crystallized, compared with the amounts present in the juices as shown by the analyses, led many to believe that the reactions were largely due to some other substance than cane sugar.

EARLY INVESTIGATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE.

During the years 1878 to 1882, inclusive, while Dr. Peter Collier was chief chemist of the Department of Agriculture, much attention was given to the study of sorghum juices from canes cultivated in the gardens of the Department, at Washington. Dr. Collier became an enthusiastic believer in the future greatness of sorghum as a sugar-producing plant, and the extensive series of analyses published by him attracted much attention from sugar-makers in the South, and students of the chemistry of sugar throughout the country.

SUGAR FACTORIES ERECTED IN KANSAS.

Stimulated by the analytical results published by Dr. Collier, interested parties erected large sugar factories and provided them with costly appliances. Hon. John Bennyworth erected one of these at Larned, in this State. S. A. Liebold & Co. subsequently erected one at Great Bend. Both of these factories made some sugar, both lost money, and both quit the business.

Sterling and Hutchinson followed with factories which made considerable amounts of merchantable sugar at no profit.

The factory at Sterling was erected by R. M. Sandys & Co., of New Orleans, who sought, by combining Mr. Sandys' thorough knowledge of

sugar with the best practical skill of the South, to establish the sorghum-sugar industry on a proper basis. For two seasons this combination worked faithfully, and while the sirup produced paid the expenses of the factory, not a crystal of sugar was made. The factory then in 1883 changed hands, and passed under the superintendency of Prof. M. A. Scovell, then of Champaign, Ill., who, with Professor Weber, had worked out, in the laboratories of the Illinois Industrial University, a practical method for obtaining sugar from sorghum in quantities which at prices then prevalent would pay a profit on the business. But prices declined, and after making sugar for two years in succession the Sterling factory succumbed.

The Hutchinson factory at first made no sugar, but subsequently passed under the management of Prof. M. Swenson, who had successfully made sugar in the laboratory of the University of Wisconsin. Large amounts of sugar were made at a loss, and the Hutchinson factory closed its doors. In 1884 Hon. W. L. Parkinson fitted up a complete sugar factory at Ottawa, and for two years made sugar at a loss. Mr. Parkinson was assisted during the first year by Dr. Wilcox, and during the second year by Professor Swenson.

INFORMATION GAINED.

Much valuable information was developed by the experience in these several factories, but the most important of all was the fact that, with the best crushers, the average extraction did not exceed half of the sugar contained in the cane. It was known to scientists and well-informed sugar-makers in this country that the process of diffusion was theoretically efficient for the extraction of sugar from plant cells, and that it had been successfully applied by the beet-sugar-makers of Europe for this purpose.

FURTHER WORK OF THE U. S. DEPARTMENT OF AGRICULTURE.

In 1883, Prof. H. W. Wiley, chief chemist of the Department of Agriculture, made an exhaustive series of practical experiments in the laboratories of the Department on the extraction of the sugars from sorghum by the diffusion process. His report sums up the results of his experiments as follows :

(1) The extraction of at least 85 per cent. of the total sugars present was secured. In many of the experiments, as will be seen by consulting the table, scarcely a trace of sugar could be detected in the exhausted chips.

(2) The production of a quantity of melada represented by from 10.9 to 12.28 per cent. of the weight of the cane diffused.

This was secured with a cane in which the total sugars did not exceed 11.68 per cent. The percentage of melada by this process will be found just about equal to the per cent. of total sugars in the cane.

It ought to be greater with a more perfect extraction, but I am speaking only of results actually obtained.

This yield is just about double that obtained by the large factories at Rio Grande, Champaign, and other places.

(3) The production of a juice of great purity, which lends itself easily to processes of depuration.

I consider the experiments, however, to have their chief value in the fact that they will call the attention of cane-growers to the advantages which a rational system of diffusion will have over pressure in the extraction of the saccharine matter.

I hope to be able at the end of another season to report further progress in this interesting problem.

In the present condition of the sorghum-sugar industry, in which it has alike to be protected from the over-zeal of its friends and the opposition of its enemies, the process of diffusion offers the most promising outlook for success. It therefore seems the duty of this division to make a more practical test of this process and on a larger scale.

To make the necessary further experiments with diffusion, required the expenditure of large sums of money. As already shown, the private companies had lost heavily. They were utterly unable to complete the experiments so hopefully begun by the Department of Agriculture.

THE AID OF CONGRESS SOLICITED.

At this crisis Hon. W. L. Parkinson and Mr. Alfred Taylor, of Ottawa, Kans., after consulting with others interested in the then languishing sorghum-sugar industry, went to Washington to call the attention of Congress to the important results promised for the diffusion process, and to show that, without the aid of an appropriation, all that had hitherto been accomplished would be practically lost. The Kansas delegation in Congress became interested. Senator Plumb made a thorough study of the entire subject, and, with the foresight of statesmanship, gave his energies to the work of securing an appropriation of \$50,000 for the development of the sugar industry. This appropriation was made during the last days of the session of 1884. The season was too far advanced to erect and use the diffusion apparatus with sorghum cane, and it was, by the Commissioner of Agriculture, sent to Louisiana, and sorghum got no benefit from this first appropriation.

ANOTHER APPROPRIATION.

In 1885, Senator Plumb, at the request of Judge Parkinson, Professor Swenson, and others, again labored for an appropriation for experiments with diffusion. It was shown by Judge Parkinson, and all others interested in the sorghum-sugar industry, that this was the only hope for success. Fifty thousand dollars for this purpose was again added to the agricultural appropriation bill, on the amendment of Senator Plumb. This was expended at Ottawa, Kans., and in Louisiana. The report of the work at Ottawa closes as follows:

(1) By the process of diffusion 98 per cent. of the sugar in the cane was extracted, and the yield was fully double that obtained in the ordinary way.

(2) The difficulties to be overcome in the application of diffusion are wholly mechanical. With the apparatus on hand the following changes are necessary in order to be able to work 120 tons per day: (a) The diffusion cells should be made twice as

large as they now are; that is, of 130 cubic feet capacity. (b) The opening through which the chips are discharged should be made as nearly as possible of the same area as a horizontal cross-section of the cell. (c) The forced feed of the cutters requires a few minor changes in order to prevent choking. (d) The apparatus for delivering the chips to the cells should be remodeled so as to dispense with the labor of one man.

(3) The process of carbonatation for the purification of the juice is the only method which will give a limpid juice with a minimum of waste and a maximum of purity.

(4) By a proper combination of diffusion and carbonatation the experiments have demonstrated that fully 95 per cent. of the sugar in the cane can be placed on the market either as dry sugar or molasses.

(5) It is highly important that the Department complete the experiments so successfully inaugurated by making the changes in the machinery mentioned above and by the erection of a complete carbonatation outfit.

Respectfully,

H. W. WILEY, *Chemist.*

But while so much had been accomplished by the joint efforts of the United States Department of Agriculture and the Ottawa company, the financial results were so disastrous to the company as to leave them utterly unable to further co-operate with the Government in the prosecution of the work.

THE FORT SCOTT COMPANY ORGANIZED.

At this juncture Judge Parkinson saw that he must either submit to defeat or organize a new company to co-operate with the Department of Agriculture, should Congress be wise enough to make another appropriation. In this straight he went to Fort Scott and organized the Parkinson Sugar Company, which is now composed as follows: J. D. Hill, president; Eli Kearnes, vice-president; M. Swenson, secretary and chemist; W. Chenault, treasurer; W. L. Parkinson, manager; C. F. Drake, A. W. Walburn, W. W. Pusey, J. W. Converse, and David Richards.

Taking up the work where all others had failed, this company has taken a full share of the responsibilities and losses, until it has at last seen the Northern sugar industry made a financial success.

THE HOUSE OF REPRESENTATIVES MAKES AN APPROPRIATION.

The report of 1885 showed such favorable results that in 1886 the House made an appropriation of \$94,000, to be used in Louisiana, New Jersey, and Kansas. A new battery and complete carbonatation apparatus were erected at Fort Scott. About \$60,000 of the appropriation was expended here in experiments in diffusion and carbonatation.

In his report Dr. Wiley arrived at the following conclusions:

In a general review of the work, the most important point suggested is the absolute failure of the experiments to demonstrate the commercial practicability of manufacturing sorghum sugar. The causes of this failure have been pointed out in the preceding pages, and it will only be necessary here to recapitulate them. They were:

(1) Defective machinery for cutting the canes and for elevating and cleaning the chips and for removing the exhausted chips.

(2) The deterioration of the cane due to much of it becoming over-ripe, but chiefly to the fact that much time would generally elapse after the canes were cut before they reached the diffusion battery. The heavy frost which came the first of October also injured the cane somewhat, but not until ten days or two weeks after it occurred.

(3) The deteriorated cane caused a considerable inversion of the sucrose in the battery, an inversion which was increased by the delay in furnishing chips, thus causing the chips in the battery to remain exposed under pressure for a much longer time than was necessary. The mean time required for diffusing one cell was twenty-one minutes, three-times as long as it should have been.

(4) The process of carbonatation, as employed, secured a maximum yield of sugar, but failed to make a molasses which was marketable. This trouble arose from the small quantity of lime remaining in the filtered juices, causing a blackening of the sirup on concentration, and the failure of the cleaning apparatus to properly prepare the chips for diffusion.

THE COMMISSIONER OF AGRICULTURE DISCOURAGED.

After the expenditure of so much money, and the publication of so discouraging a report as that of 1886, the Commissioner of Agriculture declined to ask for further appropriations.* But Senator Plumb again came to the rescue, and, by a faithful presentation of the possibilities of the case, induced Congress to make an appropriation of \$50,000, of which \$24,000 was apportioned to Louisiana, \$6,000 to Rio Grande, N. J., and \$20,000 to Fort Scott, Kans.†

SUCCESS AT LAST.

This year the Fort Scott management made careful selection of essential parts of the processes already used, omitted non-essential and cumbersome processes, availed themselves of all the experience of the past in this country, and secured a fresh infusion of experience from the beet-sugar factories of Germany, and attained the success which finally places sorghum sugar-making among the profitable industries of the country.

STATE ENCOURAGEMENT.

The State of Kansas had, by all reports, been indicated as the center of the sorghum-sugar industry, when it should be developed. Kansas statesmen in the legislature, as early as 1885, conceded that the State should assist in the development of the new industry. In that year Hon. R. F. Bond, member of the house from Rice County, prepared and introduced a bill providing for a bounty of 1½ cents per pound, to be paid out of the State treasury, on all sugar manufactured in the State

* The non-action of the Commissioner is misunderstood by Mr. Cowgill. When the House Committee on Agriculture made the appropriation of the preceding year it was agreed that no subsequent grant should be demanded. It was in harmony with this agreement and not for the reasons stated that the Commissioner did not ask for a further appropriation.

† The distribution of the money to the various stations was left to the discretion of the Commissioner, and was not mentioned in the bill.

for five years. The bill awakened a great deal of enthusiasm, and, at the same time, a factious opposition, and was lost. At the session of 1887 Senator Bawden, of Bourbon County, introduced a bill providing for a bounty of 2 cents per pound, to be paid upon all sugar manufactured in the State for five years, the maximum amount to be paid in any year being limited to \$15,000. This bill became a law.

It will thus be seen that the present condition of the sorghum-sugar industry is due to private enterprise, aided by Government and State appropriations, and directed by scientific and practical skill.

COMMISSIONERS OF AGRICULTURE LE DUC, LORING, AND COLMAN.

It should be mentioned in this connection that United States Commissioner of Agriculture Le Duc extended a strong and friendly hand to the sorghum-sugar industry during his term of office. His successor, Commissioner Loring, had the work continued by Professor Wiley, but was himself skeptical as to results. The present Commissioner, Hon. Norman J. Colman, had been an advocate of sorghum for many years before his accession to office, and had probably written and published more on the subject than any other man in the United States. Every friend of the struggling industry was gratified at his appointment. He has extended all the aid at his command, and may justly feel proud of the attainment of the present success under his administration of the Department of Agriculture.

THE PRESENT STATE OF THE INDUSTRY.

The experiments in making sugar from sorghum, which, as above shown, have been in progress for several years at the expense of private capital and the United States Department of Agriculture, have this year reached so favorable results as to place the manufacture of sorghum sugar on the basis of a profitable business, as will be seen by the report to his company of Hon. W. L. Parkinson, manager of the Fort Scott works.

The success has been due to, first, the almost complete extraction of the sugars from the cane by the diffusion process; second, the prompt and proper treatment of the juice in defecating and evaporating; third, the efficient manner in which the sugar was boiled to grain in the strike-pan. That these results may be duplicated and improved upon will be readily understood from the showing made in Mr. Parkinson's report, and the descriptions of methods and processes used, and the discussion of the same as they appear in the subsequent pages of this paper.

REPORT OF W. L. PARKINSON.

To the Board of Directors Parkinson Sugar Company:

GENTLEMEN: I respectfully submit for your consideration the following report of the operations of the works of your company for the season just closing:

It is provided in our contract with the United States Department of Agriculture that certain experiments in sugar-making shall be made by the Department with certain machinery of its own and at its own expense, using the company's plant and

machinery. Many of those experiments have been so closely allied to and dovetailed into the regular work of the factory that it is very difficult, if not wholly impossible, to clearly separate the cost of the experimental work from that of the general operation of the factory during the season. At the same time it is highly important that you know as precisely as possible the cost of working and the profit or loss on each ton of cane handled.

As you are aware, the crop of cane contracted for last spring was very much less than the capacity of our works to consume. It was considered prudent to limit our danger from loss, by reason of the experimental nature of the work, and at the same time to have sufficient cane to determine thoroughly the value of the work on a practical manufacturing basis. This has been done, though it is now apparent that had the crop been twice as large, the expenses for working it would have been relatively much less. Indeed, a crop double the size of the one just finished could have been worked in about the same time, and at a comparatively trifling additional expense. The plans, methods, and processes which have made the work of the season successful beyond our most sanguine expectations, were adopted early in the season, so that the risks incident to experiments taken into account when contracting for a crop were reduced to the minimum. The fact that at least a portion of these highly successful processes were not tried and adopted last season was no fault of your company, nor of any one connected with this season's work.

To arrive at the cost per ton of cane worked, let us take the working of a single average day, when in full operation, and apart from the cost of experiments referred to.

The capacity of our factory, aside from deficient centrifugals, is limited to the capacity of the diffusion battery. Working twenty-two hours per day, this battery can comfortably handle 135 tons of chips, or cleaned cane. This represents a capacity of field cane, or cane with seed tops and blades, of about 170 tons. To handle this, aside from curing and handling seed, cost us per day of twenty-two hours, when running regularly, as follows:

1 weighmaster, at \$2.....	\$2.00
1 team, pulling cane onto storage racks, at \$2.50.....	2.50
5 men, unloading and getting cane to cutters, 22 hours, at 12½ cents.....	13.75
1 man, cutting machine, at 15 cents.....	3.30
1 man, cleaning machine, at 12½ cents.....	2.75
1 man, grinder, etc., at 15 cents.....	3.30
1 man, oiler, at 15 cents.....	3.30
3 men, diffusion battery, 1 at car and 2 above, at 12½ cents.....	8.25
1 man, diffusion battery, director of battery, at 20 cents.....	4.40
2 men, defecating, at 15 cents.....	6.60
2 men, double effects, at 15 cents.....	6.60
1 man, strike-pan, at \$5.....	5.00
1 man, hot room, at 12½ cents.....	2.75
1 man, barreler, at 12½ cents.....	2.75
2 men, centrifugals, at 15 cents.....	6.60
1 man, machinist, at \$3.....	3.00
2 men, engineers, at 20 cents.....	4.40
5 men, firemen, at 15 cents.....	16.50
2 men, roustabouts, at 12½ cents.....	5.50
1 man, water boy.....	2.00
1 man, night watch.....	1.50
2 men, foremen, at \$2.50.....	5.00
Total cost of labor.....	111.75
Oil, etc.....	2.50
Coal, 23 tons slack, at 90 cents.....	20.70
Total.....	134.75

This makes the cost of working a ton of cleaned cane, with a factory of the capacity of ours, about \$1 per ton for labor and fuel, or 90 cents per ton of field cane. The cost per ton for salaries, insurance, wear and tear, etc., must depend, of course, not only upon the size of the salaries and other general expenses, but the number of tons worked. This plant, rated as above, is capable, in seventy days, of working 9,450 tons of chips, or 11,900 tons of field cane. There is necessarily considerable expense in preparing for the season's work, and again in closing up. Allowing liberally for this and for the proper management and control of the works, we may still bring our total expenses, outside the cost of labor and fuel, at \$1 per ton upon the above basis. Add to this the cost of labor and fuel, and we have \$2 per ton as the total cost per ton of working cleaned cane. These figures are fully verified by our pay-rolls, coal bills, and other expenses while working to our capacity during the season, separated from expenditures in the completion and changing of machinery directly connected with experiments made. And to work a factory with a capacity at least one-half greater than this one would require very little additional expense except in the matter of fuel, and that would be relatively less. It seems to me a very conservative basis, with a factory of the capacity of ours, to place the actual cost of manufacture at \$2 per ton of cane; and with such a factory as I have indicated, and with a season of, say, seventy days, it is safe to place the cost of manufacture at considerably less than that sum. It requires but little figuring upon this basis, and with the cost of cane at \$2 per ton, and the yield of cane and product secured this year, to show that we have here developed a business of great interest and profit to our State and Nation.

To run a factory at the maximum profit it must be operated constantly during the working season. The loss this season by reason of the irregular operation of the factory for want of sufficient cane was very considerable. During the whole season the factory was operated but three whole days of twenty-two hours each. Some idea of the loss from this source may be gathered from the fact that not less than 2 tons of chips were lost at each break in the operation of the diffusion battery. Sixty-five such breaks or stoppages were made while running for sugar. With a larger crop of cane and better arrangements for delivery upon the part of the larger contractors, but little or no difficulty from this source need be apprehended in the future.

	Tons.
Total cane bought	3,840
Total seed tops bought	437
Total field cane	4,277

This represents the crop, less about 30 tons of seed tops yet to come in, from about 450 acres of land. There were something over 500 acres planted. Some of it failed to come at all, some "fell upon the rocky places, where they had not much earth, and when the sun was risen they were scorched;" so that, as nearly as we can estimate, about 450 acres of cane were actually harvested and delivered at the works. This would make the average yield of cane $9\frac{1}{2}$ tons per acre, or \$19 per acre in dollars and cents. I beg to observe, in this connection, that the present was the lightest in tonnage of the five successive crops I have handled. It was probably also the poorest in crystallizable sugar, covering the same period of time, in the State. It may not be amiss to observe, too, in this connection, that a very commonly accepted theory, that "the dryer the weather the sweeter the cane," is not verified by my experience.

Of the total cane worked, 162 tons were consumed in experiments with our cutters and cleaning machinery before the cane was ripe enough for use for either sirup or sugar. No product whatever, not even seed, was saved from this, nor from 10 tons additional brought in since the factory closed down. About 300 tons of mostly down and inferior cane was worked in the early part of the season on the crushers, and without diffusion. The only product from this was molasses, and of that but a small quantity. About 375 tons were also worked for molasses only on the diffusion battery. This, with the exception of 50 tons at the close of the season, and which came in too irregularly to be worked for sugar, was worked before the sugar season began, and

comprised such down patches and poorer quality of cane as could be gathered, mainly on the lands belonging to the company. It was an open question whether very poor cane could be worked successfully, even for sirups, on a diffusion battery. Nothing in this direction had hitherto been attempted. The total yield of molasses from this source, and from which no sugar has been taken, is 4,157 gallons. From this are sold 3,157 gallons, for \$726.71 net. The remaining 1,000 gallons are still on hand, and are worth 25 cents per gallon.

Deducting from total tonnage, less seed	Tons. 3,840
Amount not worked for sugar	897
We have total cane and leaves for sugar	2,943

The total number of diffusion cells worked for sugar is 2,643. The weight of a cell of chips is 1,975 pounds. With this as a basis there was worked by diffusion for sugar 2,610 tons of clean cane as it entered the cells. Deducting this from 2,943 tons of cane, with leaves and blades, and we have 333 tons of leaves and blades. The latter are to us a dead loss. A small portion has been hauled away by farmers for feed, but the bulk of this large tonnage is now fit only for manure. This waste was considerably increased by the failure of our separating machines, especially in the early part of the season, to properly discharge their duties. This whole subject was new; machines had to be devised, and their adjustment, which is not yet perfect, caused considerable loss of cane. The weight of blades and leaves will not be far from 10 per cent. of field cane. For either feed or fuel, especially where the latter is much of an object, the blades can be utilized so as to at least cover their own cost. At present we figure the loss from this source to seed account.

SEED.

There have been delivered of seed tops 437 tons. As nearly as we can estimate, there are yet to be delivered 30 tons, making in all 467 tons. From the best calculations we can make, and judging from our experience in former years, seed yields about 70 per cent. of the weight of heads, as bought in over the scales, in cleaned seed. Putting it at 60 per cent., and with 56 pounds to the bushel, we shall have 19,000 bushels of cleaned seed. A portion of this, estimated at 1,000 bushels, has, at considerable additional expense, been picked over by hand, head by head, tied into small bundles, and hung up in the dry. This has been done to provide ourselves with pure seed of the different varieties for planting, and to supply a probable want in the same direction from others. For this hand-picked seed we expect to get not less than \$2 per bushel. The cost of handling the seed has not been kept separate from the cost of running the factory. The total cost of curing, stacking, and hand-picking will not be far from \$700, fully \$200 of which has been expended in securing pure and perfectly cured seed for ourselves and others willing to pay the extra price. To thrash and prepare the seed for market the seed will cost about 6 cents per bushel additional. I estimate that we shall get for our seed crop \$7,000 net. There will be left of seed tops, after thrashing, fully 100 tons. These are good for feed or fuel.

SIRUPS.

The bulk of our sirups are stored in the large cistern or cellar under the warehouse. The amount on hand we estimate at 50,000 gallons. This includes the whole crop, except the 3,157 gallons sold in early part of season. Of this we have sold, to be delivered within thirty days, and one car-load of which has already gone, 250 barrels, or about 12,500 gallons, at a price that will net us here 20 cents. This sale includes the bulk of our poorest sirups. I think we can safely estimate our sirup product, exclusive of packages, at \$10,000. Considering the condition of our factory for work in cold weather, and the limited capacity of our centrifugal machinery, I recommend their sale, without boiling, for seconds.

SUGAR.

Of our sugar product, the State inspector, Prof. E. B. Cowgill, has weighed and certified for State bounty 206,326 pounds. We have now in addition and ready for inspection 22,500 pounds. The centrifugals are still running. We estimate that we shall still have, exclusive of seconds, from 7,000 to 10,000 pounds, or, in all, 235,826 pounds. This, at 5½ cents, present price to jobbers, will produce us \$13,559.98. To this add the State bounty of 2 cents per pound, and we have for our total sugar product \$17,276.50.

TOTAL PRODUCT OF THE SEASON.

*Sugar, 235,826 pounds, at 5½ cents	\$13,559.98
Sugar, State bounty, at 2 cents	4,716.52
	17,276.50
Sirups, 51,000 gallons (estimated), at 20 cents	10,200.00
Seed (estimated)	7,000.00
Value of total product	34,476.50

TOTAL COST.

Cane, 3,840 tons, at \$2	7,680.00
Seed, 967 tons, at \$2	1,934.00
	9,614.00
Labor bill from August 15 to October 15, including labor for Department experiments	5,737.16
Coal, including all experiments	1,395.77
Salaries, etc	3,500.00
Insurance, sundries, etc	1,500.00
Total	21,746.93
Total value	34,476.50
Total cost	21,246.93
Net	13,229.57
Of the above labor bill, there has been paid—	
By the Department	2,575.21
By the company	3,161.79
Of the above coal bill, there has been paid—	
By the Department	324.00
By the company	1,071.77
Of the above cane account, there has been paid—	
By the Department	324.00
By the company	9,290.00

Or, of the above expenditures the Department has paid \$3,234.75. Bills are now pending for \$3,300, making in all \$6,534.75, reducing our total cost from \$21,746.93 to \$15,212.18, and leaving a profit from the season's work of \$19,764.32. It will thus be seen that in the working of the crop, including cane for experimental purposes, the Department of Agriculture has paid or been charged with \$6,534.75. This includes

* The amount of sugar branded was 234,607 pounds. The number of cells full of cane from which the juice was boiled for sugar was 2,501, according to the record of the sugar-boiler.—E. B. C.

the labor for the various experiments, the changing and erection of new machinery for the trial of the same, and the salaries and wages of most of the high-priced help, and which, in the practical operation of a factory, will not be required.

Respectfully submitted.

W. L. PARKINSON,
Manager.

FORT SCOTT, KANS., October 23, 1887.

OUTLINE OF THE PROCESSES OF SUGAR-MAKING.

As now developed, the processes of making sugar from sorghum are as follows:

First, The topped cane is delivered at the factory by the farmers who grow it.

Second, The cane is cut by a machine into pieces about $1\frac{1}{4}$ inches long.

Third, The leaves and sheaths are separated from the cut cane by fanning mills.

Fourth, The cleaned cane is cut into fine bits called chips.

Fifth, The chips are placed in iron tanks, and the sugar "diffused"—soaked out with hot water.

Sixth, The juice obtained by diffusion has its acids nearly or quite neutralized with milk of lime, and is heated and skimmed.

Seventh, The defecated or clarified juice is boiled to a semi-sirup in vacuum pans.

Eighth, The semi-sirup is boiled "to grain" in a high vacuum in the "strike-pan."

Ninth, The mixture of sugar and molasses from the strike-pan is passed through a mixing machine into centrifugal machines, which throw out the molasses and retain the sugar.

DETAILS OF THE PROCESSES OF SUGAR-MAKING.

An account of the processes of sugar-making ought doubtless to begin with the planting and cultivation, growth and ripening, of the cane, for it is here that the sugar is made. No known processes of science or art, save those of plant growth, produce the peculiar combination of carbon with the elements of water which we call sugar. Not only is this true, but the chemist utterly fails in every attempt to so modify existing similar combinations of these elements as to produce cane sugar. It will be interesting here to note three substances of nearly the same composition, viz: Starch, sucrose or cane sugar, and glucose or grape sugar. Their compositions are much alike, and may be stated as follows:

	Carbon.	Water.
Starch *.....	12	10
Cane sugar	12	11
Grape sugar	12	12

* The chemical formulas for these compounds are: Starch, $C_6H_{10}O_5$; cane sugar, $C_{12}H_{22}O_{11}$; grape sugar, $C_6H_{12}O_6$; in which C represents an equivalent of carbon, H of hydrogen, and O of oxygen, or H_2O an equivalent of water.

The chemist produces glucose, or grape sugar, from either starch or sugar by treatment with acid, but all attempts have failed to produce cane sugar from either starch or grape sugar.

THE FARMER THE REAL SUGAR-MAKER.

The farmer then, or perhaps more accurately the power which impels the plant to select and combine in proper form and proportions the three elements, carbon, hydrogen, and oxygen, is the real sugar-maker. All after processes are merely devices for separating the sugar from the other substances with which it grows.

HOW IS THE SUGAR FORMED IN THE CANE ?

The process of the formation of sugar in the cane is not fully determined ; but analyses of canes made at different stages of growth show that the sap of growing cane contains a soluble substance having a composition and giving reactions similar to starch. As maturity approaches, grape sugar is also found in the juice. A further advance towards maturity discloses cane sugar with the other substances, and at full maturity perfect canes contain much cane sugar and little grape sugar and starchy matter.

In sweet fruits the change from grape sugar to cane sugar does not take place, or takes place but sparingly. The grape sugar is very sweet, however.

INVERSION OR CHANGE OF CANE SUGAR INTO GRAPE SUGAR.

Cane sugar, called also sucrose or crystallizable sugar, when in dilute solution, is changed very readily into grape sugar or glucose, a substance which is much more difficult than cane sugar to crystallize. This change, called inversion, takes place in overripe canes ; it sets in very soon after cutting in any cane during warm weather ; it occurs in cane which has been injured by blowing down or by insects or by frost, and it probably occurs in cane which takes a second growth after nearly or quite reaching maturity.

Inversion will be further considered in another place.

THE FARMER'S PART MOST IMPORTANT OF ALL.

Since sugar is produced only by nature's processes of growth and is easily lost through inversion, it is evident that the farmer's part in the process of sugar-making is first and most important of all. It is a subject which invites most careful, scientific, and practical attention, and will be further considered under the subject "Improving the cane."

It is apparent from what has already been said, that to insure a successful outcome from the operations of the factory, the cane must be so planted, cultivated, and matured as to make the sugar in its juice ;

that it must be delivered to the factory very soon after cutting; and that it must be taken care of before the season of heavy frosts.

THE WORK AT THE FACTORY.

THE FIRST CUTTING.

The operations of the factory are illustrated in the large drawing, to which the reader is referred in tracing the successive steps. The first cutting is accomplished in the ensilage or feed-cutter. This cutter is provided with three knives, fastened to the three spokes of a cast-iron wheel, which makes about 250 revolutions per minute, carrying the knives with a shearing motion past a dead knife. By a forced feed the cane is so fed as to be cut into pieces about $1\frac{1}{4}$ inches long. This cutting frees the leaves and nearly the entire sheaths from the pieces of cane. By a suitable elevator the pieces of cane, leaves, and sheaths are carried to the second floor.

THE CLEANING.

The elevator empties into a hopper, below which a series of four or five fans is arranged one below the other. By passing down through these fans the cane is separated from the lighter leaves much as grain is separated from chaff. The leaves are blown away, and finally taken from the building by an exhaust fan. This separation of the leaves and other refuse is essential to the success of the sugar-making, for in them the largest part of the coloring and other deleterious matters are contained. If carried into the diffusion battery these matters are extracted (see reports of Chemical Division, U. S. Department of Agriculture), and go into the juice with the sugar. As already stated, the process of manufacturing sugar is essentially one of separation. The mechanical elimination of these deleterious substances at the outset at once obviates the necessity of separating them later and by more difficult methods, and relieves the juice of their harmful influences. From the fans the pieces of cane are delivered by a screw carrier to an elevator, which discharges into

THE FINAL CUTTING-MACHINE.

on the third floor. This machine consists of an 8-inch cast-iron cylinder with knives like those of a planing-machine. It is really three cylinders placed end to end on the same shaft, making the entire length 18 inches. The knives are inserted in slots and held in place with set-screws. The cylinder revolves at the rate of about 1,200 per minute, carrying the knives past an iron dead knife, which is set so close that no cane can pass without being cut into fine chips. From this cutter the chips of cane are taken by an elevator and a conveyor to the cells of the diffusion battery. The conveyor passes above and at one side of

the battery, and is provided with an opening and a spout opposite each cell of the battery. The openings are closed at pleasure by a slide. A movable spout completes the connection with any cell which it is desired to fill with chips.

WHAT IS DIFFUSION ?

The condition in which the sugars and other soluble substances exist in the cane is that of solution in water. This sweetish liquid is contained, like the juices of plants generally, in cells. The walls of these cells are porous. It has long been known that if a solution of sugar in water be placed in a porous or membranous sack and the sack placed in water, an action called osmose takes place, whereby the water from the outside and the sugar solution from the inside of the sack each pass through until the liquids on the two sides of the membrane are equally sweet. Other substances soluble in water behave similarly, but sugar and other readily crystallizable substances pass through much more readily than uncrystallizable or difficultly crystallizable bodies. To apply this property to the extraction of sugar the cane is first cut into fine chips, as already described, and put into the diffusion cells, where water is applied and the sugar is displaced.

WHAT HAS TAKEN PLACE IN THE DIFFUSION CELLS.

For the purpose of illustration, let us assume that when a cell has been filled with chips just as much water is passed into the cell as there was juice in the chips. The process of osmose or diffusion sets in, and in a few minutes there is as much sugar in the liquid outside of the cane cells as in the juice in these cane cells; *i. e.*, the water and the juice have divided the sugar, each taking half. Again, assume that as much liquid can be drawn from one as there was water added. It is plain that if the osmotic action is complete the liquid drawn off will be half as sweet as cane juice. It has now reached fresh chips in two, and again equalization takes place. Half of the sugar from one was brought into two, so that it now contains $1\frac{1}{2}$ portions of sugar, dissolved in 2 portions of liquid, or the liquid has risen to $\frac{3}{4}$ of the strength of cane juice. This liquid having $\frac{3}{4}$ strength passes to three, and we have in three $1\frac{3}{4}$ portions of liquid, or after the action has taken place the liquid in three is $\frac{7}{8}$ strength. One portion of this liquid passes to four, and we have $1\frac{7}{8}$ portions of sugar in 2 portions of liquid, or the liquid becomes $\frac{15}{16}$ strength. One portion of this liquid passes to five, and we have in five $1\frac{15}{16}$ portions of sugar in 2 portions of liquid, or the liquid is $\frac{31}{32}$ strength. It is now called *juice*, and is drawn off and subjected to the processes of the subsequent operations of the factory. From this time forward a cell is drawn for every one filled.

<i>a</i>	1	2	3	4	5	6	7	8	9	10	11	12
1	w											
2	w	l										
3	w	l	l									
4	w	l	l	l								
5	w	l	l	l	l							
6	w	l	l	l	l	l						
7	w	l	l	l	l	l	l					
8	w	l	l	l	l	l	l	l				
9	w	l	l	l	l	l	l	l	l			
10		w	l	l	l	l	l	l	l	l		
11			w	l	l	l	l	l	l	l	l	
12				w	l	l	l	l	l	l	l	l
13	j				w		l	l	l	l	l	l
14	l	j				w	l	l	l	l	l	l
15	l	l	j				w	l	l	l	l	l
16	l	l	l	j				w	l	l	l	l
17	l	l	l	l	j				w	l	l	l
18	l	l	l	l	l	j				w	l	l
19	l	l	l	l	l	l	j				w	l
20	l	l	l	l	l	l	l	j				w
21	w		l	l	l	l	l	l	j			
22		w	l	l	l	l	l	l	l	j		
23			w	l	l	l	l	l	l	l	j	
24				w	l	l	l	l	l	l	l	j
25	j				w		l	l	l	l	l	l
26	l	j				w	l	l	l	l	l	l
27	l	l	j				w	l	l	l	l	l
28	l	l	l	j				w	l	l	l	l
29	l	l	l	l	j				w	l	l	l

Throughout the operation the temperature is kept as near the boiling point as can be done conveniently without danger of filling some of the battery cells with steam. Diffusion takes place more rapidly at high than at low temperatures, and the danger of fermentation, with the consequent loss of sugar, is avoided. The process will be readily understood from the above diagram, in which the columns represent the cells of the battery, the numbers at the left the number of diffusions; *w*, water; *l*, liquid in the cells, or passing through them, and *j*, juice to be drawn.

INVERSION OF SUGAR IN THE DIFFUSION CELLS.

In the experiments at Fort Scott in 1886 much difficulty was experienced on account of inversion of the sugar in the diffusion battery. The report shows that this resulted from the use of soured cane and from delays in the operation of the battery on account of the imperfect working of the cutting and elevating machinery, much of which was then experimental. Under the circumstances, however, it became a matter of the gravest importance to find a method of preventing this inversion without in any manner interfering with the other processes. On the suggestion of Professor Swenson a portion of freshly precipitated carbonate of lime was placed with the chips in each cell. In the case of soured cane this took up the acid which otherwise produced inversion. In case no harmful acids were present this chalk was entirely inactive. Soured canes are not desirable to work under any circumstances, and should be rejected by the chemist and not allowed to enter the factory. So, also, delays on account of imperfect machinery are disastrous to profitable manufacturing and must be avoided. But for those who de-

sire to experiment with deteriorated canes and untried cutting-machines, the addition of the calcium carbonate provides against disastrous results which would otherwise be inevitable.

CLARIFYING OR DEFECATING THE JUICE.

Immediately after it is drawn from the diffusion battery the juice is taken from the measuring tanks into the defecating tanks or pans. These are large, deep vessels, provided with copper steam coils in the bottom for the purpose of heating the juice. Sufficient milk of lime is added here to nearly or quite neutralize the acids in the juice, the test being made with litmus paper. The juice is brought to the boiling point, and as much of the scum is removed as can be taken quickly. The scum is returned to the diffusion cells, and the juice is sent by a pump to the top of the building, where it is boiled and thoroughly skimmed. These skimmings are also returned to the diffusion cells.

This method of disposing of the skimmings was suggested by Mr. Parkinson. It is better than the old plan of throwing them away to decompose and create a stench about the factory. Probably a better method would be to pass these skimmings through some sort of filter, or perhaps better still, to filter the juice and avoid all skimming. After this last skimming the juice is ready to be boiled down to a thin sirup, in

THE DOUBLE-EFFECT EVAPORATORS.

These consist of two large closed pans provided within with steam pipes of copper, whereby the liquid is heated. They are also connected with each other and with pumps in such a way as to reduce the pressure in the first to about three-fifths and in the second to about one-fifth the normal atmospheric pressure.

The juice boils rapidly in the first at somewhat below the temperature of boiling water, and in the second at a still lower temperature. The exhaust steam from the engines is used for heating the first pan, and the vapor from the boiling juice in the first pan is hot enough to do all the boiling in the second, and is taken into the copper pipes of the second for this purpose. In this way the evaporation is effected without so great expenditure of fuel as is necessary in open pans, or in single-effect vacuum pans, and the deleterious influences of long-continued high temperature on the crystallizing powers of the sugar are avoided.

From the double effects the sirup is stored in tanks ready to be taken into the strike-pan, where the sugar is crystallized.

THE FIRST CHANCE TO PAUSE.

At this point the juice has just reached a condition in which it will keep. From the moment the cane is cut in the fields until now every delay is liable to entail loss of sugar by inversion. After the water is put into the cells of the battery with the chips, the temperature is care-

fully kept above that at which fermentation takes place most readily, and the danger of inversion is thereby reduced. But with all the precautions known to science up to this point the utmost celerity is necessary to secure the best results. There is here, however, a natural division in the process of sugar-making, which will be further considered under the heading of "auxiliary factories." Any part of the process heretofore described may be learned in a few days by workmen of intelligence and observation who will give careful attention to their respective duties.

BOILING THE SIRUP TO GRAIN THE SUGAR.

This operation is the next in course, and is performed in what is known at the sugar factory as the strike-pan, a large air-tight vessel from which the air and vapor are almost exhausted by means of a suitable pump and condensing apparatus. As is the case with the saccharine juices of other plants, the sugar from sorghum crystallizes most readily at medium temperature. There are two ways of proceeding. The simplest is to boil the sirup in the vacuum pan until it has reached about the density at which crystallization begins, then draw it off into suitable vessels and set it away in a hot room (about 110° to 120° F.) to crystallize slowly. The proper density is usually judged by the boiler, by observing the length to which a sample of the hot liquid from the pan can be drawn. This is called the "string proof" test. A far better method is to "boil to grain" in the pan. This is better because it gives the operator control of the size of the grain within certain limits, because it gives a better appearing sugar, and more important still, because with proper skill it gives a better yield. Several descriptions of this delicate operation have been published. After reading some of the best of these, the writer found, on attempting to boil to grain, that more definite instruction was necessary; and after obtaining the instruction it became apparent that while almost any one can learn to "boil to grain," yet to obtain the best yield requires personal skill and powers of observation and comparison which will be obtained in widely different degrees by different persons. To become a good sugar-boiler, one must be an enthusiastic specialist. The Parkinson Sugar Company were fortunate in securing for this important work the services of Mr. Frederick Hinze, a native of Hanover, Germany, and a graduate of the "Sugar Industry School" at Braunschweig. Though a young man, Mr. Hinze has had a large experience, having assisted his brother in the erection and operation of sugar factories in Germany, and since coming to America having worked in the beet sugar factory at Alvarado, Cal., and in cane-sugar factories in Louisiana and in Cuba. Since the close of the working season at Fort Scott, Mr. Hinze has again gone to Louisiana and taken charge of a strike-pan at the sugar house of Ex-Governor Warmoth, where he worked last season.

The process of boiling to grain may be described as follows: A portion of the sirup is taken into the pan, and boiled rapidly *in vacuo* to

the crystallizing density. If in a sirup the molecules of sugar are brought sufficiently near to each other through concentration—the removal of the dissolving liquid—these molecules attract each other so strongly as to overcome the separating power of the solvent, and they unite to form crystals. Sugar is much more soluble at high than at low temperatures, the heat acting in this as in almost all cases as a repulsive force among the molecules. It is therefore necessary to maintain a high vacuum in order to boil at a low pressure, in boiling to grain. When the proper density is reached, the crystals sometimes fail to appear, and a fresh portion of cold sirup is allowed to enter the pan. This must not be sufficient in amount to reduce the density of the contents of the pan below that at which crystallization may take place. This cold sirup causes a sudden though slight reduction of temperature, which may so reduce the repulsive forces as to allow the attraction among the molecules to prevail, resulting in the inception of crystallization. To discover this requires the keenest observation. When beginning to form, the crystals are too minute to show either form or size, even when viewed through a strong magnifying glass. There is to be seen simply a very delicate cloud. The inexperienced observer would entirely overlook this cloud, his attention probably being directed to some curious globular and annular objects, which I have nowhere seen explained. Very soon after the sample from the pan is placed upon glass for observation the surface becomes cooled and somewhat hardened. As the cooling proceeds below the surface contraction ensues, and consequently a wrinkling of the surface, causing a shimmer of the light in a very attractive manner. This, too, is likely to attract more attention than the delicate, thin cloud of crystals, and may be even confounded with the reflection and refraction of light, by which alone the minute crystals are determined. The practical operator learns to disregard all other attractions, and to look for the cloud and its peculiarities. When the contents of the pan have again reached the proper density another portion of sirup is added. The sugar which this contains is attracted to the crystals already formed, and goes to enlarge these rather than to form new crystals, provided the first are sufficiently numerous to receive the sugar as rapidly as it can crystallize.

The contents of the pan are repeatedly brought to the proper density, and fresh sirup added, as above described, until the desired size of grain is obtained, or until the pan is full. Good management should bring about these two conditions at the same time. If a sufficient number of crystals has not been started at the beginning of the operation to receive the sugar from the sirup added, a fresh crop of crystals will be started at such time as the crystallization becomes too rapid to be accommodated on the surfaces of the grain already formed. The older and larger crystals grow more rapidly, by reason of their greater attractive force, than the newer and smaller ones on succeeding additions of sirup, so that the disparity in size will increase as the work

proceeds. This condition is by all means to be avoided, since it entails serious difficulties on the process of separating the sugar from the molasses. In case this second crop of crystals, called "false grain" or "mush sugar," has appeared, the sugar boiler must act upon his judgment, guided by his experience, as to what is to be done. He may take enough thin sirup into the pan to dissolve all of the crystals, and begin again, or, if very skillful, he may so force the growth of the false grain as to bring it up to a size that can be worked.

No attempt will be made here to describe the methods of "boiling for yield," nor to point out the methods by which many special difficulties are to be overcome. Not only does the limited experience of the writer make him hesitate to enter upon these intricate subjects, but their discussion would unduly extend this report. It may be remarked that the handling of the cane, the treatment of the juice, and the preparation of the sirup, have much to do with the difficulties and success of this the most intricate of all.

THE FINAL SEPARATION OF THE SUGAR FROM THE MOLASSES.

The completion of the work in the strike-pan leaves the sugar mixed with molasses. The mixture is called *melada* or *masse cuite*. It may be drawn off into iron sugar wagons and set in the hot room above mentioned, in which case still more of the sugar which remains in the un-crystallized state generally joins the crystals, somewhat increasing the yield of "first sugar." At the proper time these sugar wagons are emptied into a mixing machine, where the mass is brought to a uniform consistency. If the sugar wagons are not used, the strike-pan is emptied directly into the mixer.

THE CENTRIFUGAL MACHINES.

From the mixer the *melada* is drawn into the centrifugal machines. These consist, first, of an iron case resembling in form the husk of mill-stones. A spout at the bottom of the husk connects with a molasses tank. Within this husk is placed a metallic vessel with perforated sides. This vessel is either mounted or hung on a vertical axis, and is lined with wire cloth. Having taken a proper portion of the *melada* into the centrifugal, the operator starts it to revolving, and by means of a friction clutch makes such connection with the engine as gives it about 1,500 revolutions per minute. The centrifugal force developed drives the liquid molasses through the meshes of the wire cloth, and out against the husk, from which it flows off into a tank. The sugar, being solid, is retained by the wire cloth. If there is in the *melada* the "false grain" already mentioned, it passes into the meshes of the wire cloth, and prevents the passage of the molasses. After the molasses has been nearly all thrown out, a small quantity of water is sprayed over the sugar while the centrifugal is in motion. This is forced through the sugar, and carries with it much of the molasses

which would otherwise adhere to the sugar, and discolor it. If the sugar is to be refined, this washing with water is omitted. When the sugar has been sufficiently dried, the machine is stopped, the sugar taken out, and put into barrels for market.

Simple as the operation of the centrifugals is, the direction of the sugar-boiler as to the special treatment of each strike is necessary, since he, better than any one else, knows what difficulties are to be expected on account of the condition in which the melada left the strike-pan.

CAPACITY OF THE SUGAR FACTORY.

It has already been shown that the operation of the diffusion battery should be continuous. The experience so far had in diffusing sorghum indicates eight minutes as the proper time for filling a cell; or one cell should be filled and another emptied every eight minutes. This, with a battery of twelve cells, nine of which are under pressure, gives seventy-two minutes as the time during which the chips are subject to the action of the water. If the chips are cut sufficiently fine, the time may be reduced to seven or even to six minutes to the cell without probable loss from poor extraction. The time may be extended to ten minutes per cell without danger of damage when working sound canes.

Taking eight minutes as the mean, we shall have one hundred and eighty as the number of cells diffused in a day. To secure the best results, all other parts of the factory must be adjusted to work as rapidly as the diffusion battery, so that the capacity of the battery will determine the capacity of the factory.

A plant having a battery like that at Fort Scott, in which the cells are each capable of containing a ton of cane chips, should then have a capacity of 180 tons of cleaned cane, or 200 tons of cane with leaves, or 240 tons of cane as it grows in the field, per day of twenty-four hours. Those who have given most attention to the subject think that a battery composed of $1\frac{1}{2}$ -ton cells may be operated quite as successfully as a battery of 1-ton cells. Such a battery would have a capacity of 360 tons of field cane per day.

SIMPLIFICATION OF THE DIFFUSION BATTERY.

The diffusion battery as used at the Parkinson factory is an intricate and expensive apparatus, and yet it is simple as compared with those first used in Germany and France. The Germans have, however, within a few years constructed batteries even simpler than that at Fort Scott. An apparatus has even been constructed composed of a single vessel through which the water passes in one direction while the chips are moved slowly in the other by a screw conveyor. The batteries which will be used in this country, however, will doubtless be constructed on the general plan of that used at Fort Scott, with such modifications as will cheapen the construction and reduce the labor of operating.

THE CUTTING AND CLEANING APPARATUS.

This consists of modifications of appliances which have long been used for other purposes. Simple as it is, and presenting only mechanical problems, the cutting, cleaning, and elevating apparatus is likely to be the source of more delays and perplexities in the operation of the sugar factory than any other part.

The diffusion battery in good hands works perfectly; the clarification of the juice causes no delays; the concentration to the condition of semi-sirup may be readily, rapidly, and surely effected in apparatus which has been brought to great perfection by long experience, and in many forms; the work at the strike-pan requires only to be placed in the hands of an expert; the mixer never fails to do its duty. There are various forms of centrifugal machines on the market, some of which are nearly perfect. If, then, the mechanical work of delivering, cutting, cleaning, and elevating the cane can be accomplished with regularity and rapidity, the operation of a well-adjusted sugar factory should proceed without interruption or delay from Monday morning to Saturday night.

The machines used at Fort Scott for these purposes have not been described in detail. They need only to be made stronger and simpler. Their general plan is not far from that which is likely to be in general use in the near future.

The methods of handling cane need some modifications as to details. The arrangement for making the factory engine unload the cane from the farmers' wagons will probably never be abandoned, since it is much more rapid and leaves the cane in better shape than it can be left by hand.

THE SCIENTIFIC WORK.

The present favorable condition of the sorghum-sugar industry, like the immense development of the beet-sugar industry of Europe, is indebted for its existence largely to long-continued scientific work; and while much of the scientific manipulation which it was once feared would be necessary to success has been eliminated in practice, yet the scientist has not been able to so far simplify the subject as to enable the manufacturer to dispense with his services. I shall try here to make a plain statement of the scientific work necessary in a sugar factory under developments so far made.

WHERE THE SCIENTIFIC WORK IS NEEDED.

It has already been shown that it is only on reaching maturity that sorghum is a profitable sugar plant. To determine when most farm products are ripe is a simple matter of inspection. But it is astonishing to note how greatly different will be the views of, say, a dozen practical farmers as to when a given field of wheat is ripe. Experience in judging of the ripeness of sorghum is far less extended than in the case

of wheat. Indeed, the varying conditions of the weather so greatly affect the appearance of ripeness, *i. e.*, the hardness of the seed, the condition of the leaves, etc., that the manufacturer, who must know before he uses cane whether it is ripe or green, is left no other than the test of chemical analysis. This determines the one point of interest to him, namely, whether the cane has reached such a degree of maturity as to have made its sugar.

Again, although the cane may have reached full maturity, if it shall have been cut and exposed to the atmospheric influences of the earlier part of the season for any considerable time, the sugar may have been changed to glucose. In moist weather this change may take place without any accompanying change in the appearance of the cane. A notable instance illustrating this kind of depreciation occurred at the Parkinson works during the season just closed. A farmer brought in a sample of excellent-looking cane. The book-keeper, who has had considerable experience about sugar factories, examined it, and after ascertaining by the hydrometer that the juice contained about 13 per cent. of dissolved solids, was about to direct the farmer to bring in the cane. An analysis showed that about 8 of this 13 per cent. was glucose, 3 per cent. sugar, and 2 per cent. other substances not more valuable than glucose. Inquiry disclosed the fact that the cane had been cut for three days. The weather had been moist, so that no change in appearance had taken place. To have worked such cane for sugar would have been worse than useless, since the glucose and other substances its juice contained would have held from crystallization not only the 3 per cent. of sugar which this cane contained, but a considerable amount more had it been worked with better juice.

Instances might be multiplied to show the perplexities and disappointments which are liable to result unless a most careful supervision be had of the condition of the cane when it enters the factory. Certainly no field of cane should be cut until the development of its sugar has been reached and determined by the best means available.

In the early part of the season, while the weather is warm, all cane cut in the forenoon should be worked the same day, and that cut in the afternoon should be worked by noon the next day. During the cooler weather of the latter part of the season it is not necessary to be quite so prompt. The delays which will be admissible can be determined by analysis of the cane.

Not only is it necessary to know that the cane enters the factory with its sugar intact, but it is important to see that it does not suffer inversion during the process of manufacture. To prevent this all delays must be avoided. The cane must go promptly and regularly through the cutters and cleaners as rapidly as it can be thoroughly diffused. In a pile of cane chips inversion of the sugar very soon begins, and is soon followed, if not accompanied, by acetic fermentation. If acetic or other active acid be present in the diffusion cells it causes rapid inversion of

the sugar under the high temperature of the battery. After leaving the battery the treatment of the juice must be prompt to guard against inversion. Indeed, as has been remarked above, every part of the factory in which the work is done until the juice has been reduced to a sirup should be of such a capacity that it can surely do its work at all times as rapidly as the battery can be operated. It is a matter of great importance to the manufacturer to know whether, at any stage of the process, inversion is taking place. To determine this the analysis of average samples of freshly-cut chips may be compared with analysis of the product at other stages. For example: To determine whether inversion is taking place in the battery, crush out and analyze the juice from samples of chips as they enter; then analyze samples of the diffusion juice as it comes from the battery. If the relation of sugar to glucose is the same in these analyses it may be concluded that no inversion is taking place. If, however, the proportion of sugar to glucose is smaller in the diffusion juice than in that obtained directly from the chips by crushing, inversion is probably taking place, and its cause must be sought and remedied.

The subsequent processes of manufacture give little occasion for inversion, unless from delay before the juice has been reduced to sirup. The safest plan is to not let it cool until it is ready for the strike-pan. If unavoidable delays lead to a suspicion that inversion may have taken place, the matter may be determined by analysis. Inversion is not the only cause of loss to be guarded against in the battery. As shown by the report of the chemist of the United States Department of Agriculture, the average extraction of the battery at the Parkinson factory this season was 92.04 per cent. of all the sugars the cane contained. A closer average extraction than 95 per cent. is scarcely to be expected, and an extraction of less than 90 per cent. should be considered inadmissible. Poor extraction may result from overhurryng the battery, from allowing the temperature to run too low, from raising the temperature too highly, thereby filling the upper parts of the cells with steam instead of water, or from improper manipulation of the valves, or from failure of the cutting machines to properly prepare the chips. The perfection of the extraction may be determined by analysis of the exhausted chips from the battery, and if not found satisfactory, the cause is of course to be sought out and remedied.

It is desirable for the manufacturer to know how much sugar he is leaving in the molasses, and also how much molasses he is leaving in the sugar; i. e., the purity of the sugar. These points are readily determined by analysis.

WHO CAN DO THIS SCIENTIFIC WORK?

It is doubtless desirable, though not essential, that the superintendent of a sugar factory be also a chemist. The analyses indicated in the above pages are not intricate. To make them all, however, will require

considerable time, and whether the superintendent be capable or incapable of making them, he will scarcely be able to spare the time which ought to be devoted to them.

Any of the graduates of our agricultural or other colleges who have taken a good course of chemistry, with laboratory practice, can by a few months' special training in sugar chemistry and practice in sugar analysis become entirely competent to do the work required in the ordinary operation of a factory, under the direction of the superintendent.

HOW TO MAKE THE ANALYSES NECESSARY IN THE SUGAR FACTORY.

It is hoped that the following discussion of the methods of making sugar analyses will be of interest to some who may engage in such work, and throw some light on the subject for the general reader. For fuller discussions of the subject, the reader is referred to Tucker's Sugar Analysis, and the bulletins of the Chemical Division, U. S. Department of Agriculture.

It is well to remember here, that on account of the sugar and other substances dissolved in it cane juice is denser than water. Thus, if 9 pounds of water and 1 pound of sugar be mixed together the water will dissolve the sugar, and any given volume of the mixture, say a pint, will weigh one and four-hundredths times as much as a pint of water. Take another illustration: A gallon of water weighs about $8\frac{1}{2}$ pounds, while a gallon of the above supposed sugar solution weighs about $8\frac{3}{4}$ pounds. If a sugar solution be made, containing 20 per cent. of its weight in sugar, a gallon of it will weigh about 9 pounds. A gallon of a solution of equal parts by weight of sugar and water weighs about $10\frac{1}{4}$ pounds, and sirups containing three parts sugar to one of water weigh about $11\frac{1}{2}$ pounds to the gallon.

THE HYDROMETER OR SACCHARIMETER.

Instruments called hydrometers or saccharimeters have been made for determining the relative amounts of sugar and water in solutions. These would be sufficiently accurate for the purposes of the manufacturer if the juice contained nothing but cane sugar and water; but the grape sugar and other substances contained in the juice increase the density in about the same proportion as it is increased by the cane sugar. While, therefore, the hydrometer is of use in determining the amount of solid matter contained in the juice, and may be used in some cases, as in determining the degree of extraction, etc., it does not determine the relative proportions of the substances present.

TWO METHODS OF ANALYSIS.

Two methods of determining the percentage of cane sugar in a sample of juice are available. These are the chemical and the optical. By the

first may be determined the percentages of, first, cane sugar; second, grape sugar, otherwise called glucose; third, "not sugar;" fourth, water; constituting the juice. By the second method, the cane sugar alone is determined. The optical method is, however, conveniently used in connection with the chemical, in making complete analyses. One of the chemical methods will be considered first. I shall go as little as possible into technicality here.

FEHLING'S SOLUTION OF COPPER.

This is the principal reagent used in the chemical methods of analysis. There are several modifications of it. Perhaps none of these is better than *Violette's solution* : *

34.64 grams pure crystallized copper sulphate.

184.00 grams tartrate soda and potash (Rochelle salt).

78.00 grams caustic soda.

The copper salt is to be dissolved in 140 cubic centimeters of distilled water, slowly added to a solution of the tartrate and caustic soda, and the whole made up to 1 liter at standard temperature ($17\frac{1}{2}^{\circ}$ Centigrade; $63\frac{1}{2}^{\circ}$ Fahrenheit). This should be a clear blue solution.

THE GRAPE-SUGAR TEST.

If now a portion of this copper solution be brought to a boil, and to it be added a solution containing grape sugar, the blue color will be changed through various shades of purple to crimson, and finally to scarlet. The reaction has reached the decisive stage when the color is crimson. On standing, the crimson precipitate settles to the bottom of the vessel. This is the reaction for the determination of grape sugar. If a definite quantity, say 10 cc., of the copper solution be used in the above experiment, a definite quantity of grape sugar, .05 grams, will have to be added to perfect the reaction. Now by noting the amount of sample added to complete the reaction, the determination of the percentage of grape sugar from the experimental data becomes a mere matter of arithmetic. Thus, if 4 grams of the sample had been added to produce the complete reaction, we should have known that those 4 grams of sample contained five-hundredths of a gram of grape sugar. $.05 \div 4 = .0125$, or $1\frac{1}{4}$ per cent. of grape sugar.

THE CANE SUGAR TEST.

Cane sugar has no such effect on the copper solution. It has been remarked already that cane sugar changes very readily into grape sugar. This change is easily produced by boiling the solution of cane sugar; for example, the cane juice with dilute hydrochloric or sulphuric acid. The cane juice will now contain the grape sugar it originally con-

* Tucker's Sugar Analysis, p. 186.

tained, and in addition that which resulted from the inversion of the cane sugar. It now only remains to nearly neutralize the acid in the solution, cool it, and execute the test and calculations for grape sugar as before. Subtracting the percentage of grape sugar originally found from that shown by the last determination gives the percentage of grape sugar resulting from the inversion of the cane sugar. The percentage of cane sugar is .95 of the grape sugar produced by inversion of the cane sugar. The soluble solids "not sugar" contained in the juice may be estimated by subtracting the sum of the percentages of the two sugars from the entire percentage of soluble solids as determined by the hydrometer.

THE OPTICAL METHOD.

The optical method of determining the percentage of cane sugar depends upon the fact that a beam of polarized light is rotated to the right in passing through a solution of this sugar. While the apparatus for executing this test is expensive and the explanation intricate, the manipulation is simple and rapid and the results satisfactory; so that it is probable that all well-regulated sugar factories will be provided with these instruments.

For many of the purposes of the factory the determinations of the percentage of cane sugar is all that is required. The analyst will probably be able to make forty or fifty of these determinations per day by the optical method, if so many are required.

THE FURTHER SCIENTIFIC WORK.

The money, skill, and knowledge which have during the last few years been expended upon the sorghum plant have made available a new industry. The possibilities of this new industry can be fully understood only on more fully considering some of the facts which chemical science has made known.

The analyses made at the Parkinson Sugar Works during the season of 1887 by Dr. C. A. Crampton and Mr. Norman J. Fake, chemists of the U. S. Department of Agriculture, are of great value in this connection, and when supplemented by the further work now in progress in the laboratories of the Department at Washington will become a basis for future work.

In tables of analyses the percentages given are usually computed on the weight of the juice contained in the cane. Those who are familiar with the habit of the plant will readily see that the cane may be considered in three parts, viz: (1) The tops, including the seed and 12 to 18 inches of the upper part of the stalk; (2) the leaves, including the leaf sheaths; (3) the body of the cane after the tops and leaves have been removed. This body of the cane contains nearly all of the juice, and practically all of the sugar.

A ton of sorghum as it grows is composed of these three parts in about the following average proportions :

Topped and cleaned cane.....	pounds..	1,500
Tops.....	do.....	300
Leaves and sheaths.....	do.....	200
Total.....		2,000

The juice constitutes about 90 per cent. of the topped and cleaned cane. Analytical estimates and the estimates of the sugar factory are based on the ton of topped and cleaned cane. In order to place the matter clearly before the reader, and at the same time to compare the amount of sugar contained in Louisiana cane with that contained in sorghum, and to make other studies of the subject, I have computed from the analytical tables of the United States Department of Agriculture the weights of "cane sugar," "grape sugar," and soluble solids "not sugar," found to exist in the ton of topped and cleaned sorghum for the years 1883-'87, and in the ton of cleaned Louisiana cane for the years 1884-'86.

"Cane sugar," "grape sugar," and soluble solids "not sugar" contained in a ton of cleaned sorghum and cleaned Louisiana cane.

[Computed from the analytical tables of the United States Department of Agriculture, the weight of juice being assumed at 1,800 pounds per ton in either cane.]

Constituents.	1883.		1884.		1885.		1886.		1887.		Means.	
	Sorghum.	Louisiana cane.*	Sorghum.†	Louisiana cane.	Sorghum.	Louisiana cane.	Sorghum.	Louisiana cane.	Sorghum.	Louisiana cane.*	Sorghum.	Louisiana cane.
Cane sugar	Lbs. 182.70	Lbs. 264.90	Lbs. 227.00	Lbs. 177.48	Lbs. 220.00	Lbs. 188.82	Lbs. 243.00	Lbs. 171.80	Lbs. 183.10	Lbs. 230.00	Lbs. 183.10	Lbs. 230.00
Grape sugar	73.44	22.32	15.66	50.00	18.00	62.00	11.00	60.00	53.55	14.89	53.55	14.89
Total sugars	236.14	287.22	242.66	227.48	238.00	250.82	254.00	231.80	246.65	244.89	246.65	244.89
Not sugar.....	30.42	64.44	47.88	50.00	44.00	55.00	37.60	50.00	49.97	43.16	49.97	43.16
Total soluble solids	266.56	351.64	290.54	277.48	282.00	305.82	291.60	281.80	296.62	288.05	296.62	288.05

* No record.

† The writer made a series of analyses of canes grown near Sterling, Kans., in 1884, taking the juice as it came from the crusher in the regular course of manufacture. The mean of these from the first mill gave 222 12 pounds of sugar per ton of cane. In his report of the crop of 1884 Dr. Wiley says the land on which the cane analyzed by him and included in the above summary was grown had a top-dressing of about 400 pounds of superphosphate per acre.

IMPROVING THE SEED.

The study of this table is most interesting. The first and most important observation is of the wide differences in the sorghum canes examined, there being a variation of 102.2 pounds of cane sugar per ton from 1883 to 1884. Every practical sugar-maker knows that the difference in the available sugar is greater than the actual difference shown in these analyses. Again, the cane sugar contained in the sorghum of 1884 exceeded that in the Louisiana cane of any year of the record.

If a naturalist were seeking a plant whose record indicated that it would yield readily to the influences of cultivation, a plant which might be changed in its characteristics, he would select one showing just such extreme variations as this. It is doubtless necessary only to reproduce the conditions, whatever they may have been, under which the crop of 1884 was produced to reproduce like results. These conditions may be no more difficult to attain than those which produce the average crop. This branch of the subject invites study and experiment. The opportunity doubtless exists to build up the sugar-producing properties of sorghum-making improvements not inferior to those by which the Europeans have made the sugar-beet a most valuable source of sugar.

In this connection, I can do no better than to produce and second the remarks of Dr. Wiley, in his report for 1883, on Improvement by Seed Selection.

I am fully convinced that the Government should undertake the experiments which have in view the increase of the ratio of sucrose to other substances in the juice. These experiments, to be valuable, must continue under proper scientific direction for a number of years. The cost will be so great that a private citizen will hardly be willing to undertake the expense.

The history of the improvement in the sugar beet should be sufficient to encourage all similar efforts with sorghum.

The original forage beet, from which the sugar beet has been developed, contained only 5 or 6 per cent. of sucrose. The sugar beet now will average 10 per cent. of sucrose. It seems to me that a few years of careful selection may secure a similar improvement in sorghum.

It would be a long step toward the solution of the problem to secure a sorghum that would average, field for field, 12 per cent. sucrose and only 2 per cent. of other sugars, and with such cane the great difficulty would be to make sirup and not sugar. Those varieties and individuals of each variety of cane which show the best analytical results should be carefully selected for seed, and this selection continued until accidental variations become hereditary qualities in harmony with the well-known principles of descent.

If these experiments in selection could be made in different parts of the country, and especially by the various agricultural stations and colleges, they would have additional value and force. In a country whose soil and climate are as diversified as in this, results obtained in one locality are not always reliable for another.

If some unity of action could in this way be established among those engaged in agricultural research, much time and labor would be saved and more valuable results be obtained.

A VALUABLE CONTENT OF SORGHUM CANE.

The grape-sugar content of sorghum is very large. When freed from such of the "not sugar" products as have an unpleasant taste, this constitutes an elegant sirup constituent. It is composed chiefly of two sugars, called, respectively, dextrose and levulose. The last is sweeter than cane sugar. This grape sugar is that to which most sweet fruits owe their sweetness. The large amount of it—over 53 pounds to the ton of cane—is likely to be recognized in the near future as one of the most valuable contents of sorghum cane.

IMPERFECT SEPARATION.

At present we are able to separate only a portion of the cane sugar from the other constituents of the juice. It is believed to be impossible by methods at present used to separate more than the difference between the cane sugar and the grape sugar. Thus the sorghum of 1883 could have yielded not more than $162.7 - 73.44 = 89.26$ pounds per ton, while that of 1884 should, by the same computation have yielded $264.9 - 22.32 = 242.58$ pounds per ton. The available sugar in the sorghum crop of 1887, by the same method, was $171.8 - 60 = 111.8$ pounds, and the average available sugar in the sorghum for the five years was $193.1 - 53.55 = 139.55$ pounds. This is supposing that the juice is all obtained from the cane, and that there is no waste in the subsequent processes. At Fort Scott, however, only a little more than 92 per cent. of the sugar was obtained from the cane, so that the above figures should be multiplied by .92, making the mean available sugar with this extraction 128.38 pounds, and the available sugar of 1887, 102.8 pounds per ton of cleaned cane.

THE YIELD OBTAINED AT FORT SCOTT.

The actual yield obtained was 234,607 pounds of first sugar, from 2,501 cells. If, now, the cell be taken as a ton, the yield of first sugar was $234,607 \div 2,501 = 93.8$ pounds. Enough of the molasses was reboiled for a second crop of crystals, and the sugar separated to ascertain that 15 to 20 pounds, per ton of cane represented, could be obtained. Calling it 15, we have for the entire yield $93.8 + 15 = 108.8$ pounds per ton of cleaned cane. This is a larger yield than is obtainable according to the heretofore accepted theory. There is some uncertainty about the weight of a cell, which may account for the discrepancy between the theoretical and the actual results. It is possible, however, that the theory may need reconstruction. In any case the yield actually obtained is most gratifying.

I have made no mention in the above of the exceptionally large yields of some special strikes made during the season. One strike gave 109 pounds of merchantable sugar for each cellful of chips. The seconds from this would doubtless have brought the yield up to 130 pounds. But the general reader and the prospective manufacturer are more interested in average than in special results. It seems safe to assume that a mean of 100 pounds of sugar and 12 gallons of molasses can be made from each ton of cleaned sorghum cane of average richness.

Science suggests several methods for the complete separation of the cane sugar from the grape sugar and the "not sugar," and further experiments in this direction should be the work of the near future. As yet almost nothing has been done towards the development of methods of separating the grape sugar from the not sugar. This subject presents a most inviting field for the chemist.

THE FUTURE OF THE SORGHUM-SUGAR INDUSTRY.

The sorghum-sugar industry now seems to have an assured future. The quantities of sugar and molasses, and other valuable products obtained from each ton of the cane and from each acre of land, well remunerate the farmer for his crop and the manufacturer for his investment and the labor and skill required to operate the factory.

An acre of land cultivated in sorghum yields a greater tonnage of valuable products than in any other crop, with the possible exception of hay. Under ordinary methods of cultivation, 10 tons of cleaned cane per acre is somewhat above the average, but the larger varieties often exceed 12, while the small Early Amber sometimes goes below 8 tons per acre. Let $7\frac{1}{2}$ tons of cleaned cane per acre be assumed for the illustration. This corresponds to a gross yield of 10 tons for the farmer, and at \$2 per ton gives him \$20 per acre for his crop. These $7\frac{1}{2}$ tons of clean cane will yield—

	Pounds.
Sugar	750
Molasses	1,000
Seed	900
Fodder (green leaves)	1,500
Exhausted chips (dried)	1,500
Total	5,650

The first three items, which are as likely to be transported as wheat or corn, aggregate 2,650 pounds per acre.

Sorghum will yield $7\frac{1}{2}$ tons of cleaned cane per acre more surely than corn will yield 30 bushels, or wheat 15 bushels per acre.

In the comparison, then, of products which bear transportation, these crops stand as follows :

Sorghum, at $7\frac{1}{2}$ tons, 2,650 pounds per acre.

Corn, at 30 bushels, 1,680 pounds per acre.

Wheat, at 15 bushels, 900 pounds per acre.

The sugar from the sorghum is worth say 5 cents per pound; the molasses, $1\frac{3}{4}$ cents per pound; the seed, $\frac{1}{2}$ cent per pound.

The products give market values as follows :

750 pounds sugar at say 5 cents*	\$37.50
1,000 pounds molasses at say $1\frac{3}{4}$ cents*	17.50
900 pounds seed at say $\frac{1}{2}$ cent*	4.50
Total value of sorghum, less fodder	59.50

The corn crop gives 1,680 pounds, at $\frac{1}{2}$ cent 8.40 |

The wheat crop gives 900 pounds, at 1 cent 9.00 |

Thus it will be seen that the sorghum yields to the farmer more than twice as much per acre as either of the leading cereals, and as a gross

* The sugar sold this year at $5\frac{1}{2}$ cents per pound, the molasses at 20 cents per gallon, and the seed at — per bushel of 56 pounds. The seed is of about equal value with corn for feeding stock.

product of agriculture and manufacture on our own soil more than six times as much per acre as is usually realized from either of these standard crops.

LENGTH OF THE SEASON FOR WORKING SORGHUM.

The season for harvesting sorghum is limited to the months during which it may be worked. At present, this dates in our southern counties from about the last of July to the middle or last of October, if a proper selection of varieties of cane has been made. Without doubt this season may, and will be, lengthened. On this point I can do no better than quote from my report to this Department in 1884:

As shown by the reports of the sugar factories of Kansas for the last two years, the working season is confined almost exclusively to the months of September and October. When the great cost of sugar-works, the expense of keeping them in repair, and the salaries of the specialists, are considered, the importance of lengthening the working season becomes painfully apparent. That a \$100,000 factory should lie idle for ten months every year, implies that it must be run at an enormous profit during the two months or fail to pay interest on the investment.

Several plans have been proposed for extending the time during which the works may run. One of these is the development of earlier varieties of cane by systematic selection of seed, cultivation, and breeding. The researches of modern physiological botanists give reason to hope for good results in this direction.

Another plan proposed is to reduce the juice to a semi-sirup in small auxiliary factories, store the semi-sirup, and make it into sugar during the winter months. This has much to commend it.

STORING CANES IN SILOS.

Experiments have been made repeatedly in keeping canes in sheds, but with indifferent success. A good deal has been done in the line of preserving green forage crops in pits, and expensive silos have been made and used. Sorghum has been laid away and kept in these with fair success.

A practical plan for keeping cane by simply covering it with a few inches of soil has been used in three experiments now on record. The first of these was made at Tilsenburgh, Ontario, in 1831-'82, by Mr. Frank Stroback, now of Sterling, Kans. Mr. Stroback has kindly handed me a copy of his record, which is given below, with the addition of the column giving the density of the juice in degrees Baumé, to render these results more easily comparable with the other analyses given in this paper.

Frank Stroback's experiment in keeping cane in silo.

When put in silo.	Baumé.	Balling.	Polarization.
October 3, 1881	8.20 to 8.80°	14.00 to 15.00°	.....
December 3, 1881	8.15	14.70	12.28
December 17, 1882	7.70	13.90	9.82
March 4, 1882	7.55	13.61	9.07

The cane used in this experiment was the early amber. The juice showed a depreciation, but the results were encouraging.

In the fall of 1883, Professor Wiley, chief chemist of the U. S. Department of Agriculture, placed a ton of early amber in a shallow pit, and placed over it a covering of earth on the grounds of the Department of Agriculture at Washington. In his report

of April 22, 1884, Professor Wiley gives an account of this experiment, from which the following information is taken :

The canes were placed in silo November 12, 1883. Numerous analyses of juices of canes similar to those preserved showed—

Sucrose, about 9 per cent.

Other sugars, about 3 per cent.

Professor Wiley's analysis of cane from silo, January 14, 1884.

Percentage of juice expressed.....	68.9
Specific gravity, 8° B.....	1.057
Percentage of sucrose.....	8.39
Percentage of other sugars.....	2.36

Analysis of cane from silo, February 27, 1884.

Percentage of juice expressed.....	73.67
Specific gravity.....	1.057
Percentage of sucrose.....	7.00
Percentage of other sugars.....	3.13

Analysis of cane from silo, April 1, 1884.

Percentage of juice expressed.....	73.81
Specific gravity.....	1.05
Percentage of sucrose.....	5.89
Percentage of other sugars.....	3.72

I was greatly interested in these results, which showed that the early amber cane can be kept during the greater part of the winter with very little depreciation of its content of sugar.

In order to extend the experiment to other varieties, and to test the possibility of keeping Kansas canes in silo, on October 15, 1884, I placed 1 ton of Link's hybrid and 1 ton of early orange in winrows between rows of stubble, and placed thereon a covering of about 2 inches of sandy soil. Analyses were made on the day on which they were buried, and subsequently, as shown in the following tables:

Analyses of juices of canes kept in silo.

Date.	Remarks.	B.	Glucose.	Sucrose.	Other solids.
EARLY ORANGE.					
1884.	(Produced by J. B. Keeloy, 2 miles southwest from Sterling.)				
Oct. 15	Cut yesterday afternoon, buried to-day.....	11.8	.55	15.62	4.73
Nov. 15	Leaves molded, canes green—interior of canes reddened to first node, top and bottom.....	10.8	4.88	10.72	3.90
Nov. 29	Appearance unchanged since 15th instant.....	10.7	4.03	9.45	5.82
Dec. 26	Appearance unchanged since November.....	9.8	1.19	11.69	4.82
1885.					
Jan. 24	126 pounds cane gave 100 pounds juice = 53½ per cent. on hand-crusher.....	11.2	4.80	10.85	4.55
LINK'S HYBRID.					
1884.					
Oct. 15	Cut and buried to-day.....	9.8	1.16	11.21	5.33
Nov. 15	Leaves molded, canes green—interior of canes reddened to first node, top and bottom.....	10.2	1.11	13.02	4.87
Nov. 29	Appearance unchanged since 15th instant.....	10.3	1.49	12.26	4.83
Dec. 26	Some of the canes show decomposition where they had been bruised.....	10.7	2.72	12.93	3.65
1885.					
Jan. 29	Small sample analyzed.....	11.0	5.49	11.40	2.91
Jan. 30	600 pounds cane gave 312 pounds juice = 52 per cent. on hand-crusher; defecated by adding milk of lime, boiling and skimming.....	11.5	5.35	11.22	4.23
Feb. 2	Above boiled to 17° B., hot, in open-fire pan.....	25.0	11.49	24.10	10.21

Samples of the canes taken from the silo on the 26th of December were sent to Professor Swenson, superintendent of the Hutchinson Sugar Works. On the 4th of January, 1885, Professor Swenson reported the following as the results of his examination of the Link's Hybrid cane:

JUICE.		Per cent.
Sucrose		15.25
Glucose		1.10
Other solids		3.94

ENTIRE CANE.		
Insoluble solids		11.72
Sucrose		13.73
Glucose		1.00
Other soluble solids		2.25
Water		71.00

Total	100.00
-------------	--------

Mr. J. C. Hart, superintendent of the farm of the Hutchinson Sugar Works, reported the following results of examinations of the Early Orange cane taken from the silo December 26:

Analysis of January 5, sucrose and glucose taken from diffusion juice.

	Per cent.
Water	67.7
Insolubles	13.9
Sucrose	14.8
Glucose	1.6
Gums, etc.	2.0
Total	100.0

Analysis of January 7, from expressed juice.

Sucrose	14.0
Glucose	3.2
Gum, etc.	4.8

On the 9th of January canes were again taken from the silo and submitted to Prof. M. A. Scovell, superintendent of the Sterling works, for analysis. The following results are taken from his report:

LINK'S HYBRID.

Amount of canes taken	pounds..	18
Amount of juice expressed	do....	7½
Juice	per cent..	41½
Density of juice, 10.6 B.		
Glucose	per cent..	5.53
Sucrose	do....	9.73

ORANGE.

Amount of canes taken	pounds..	12
Amount of juice, 4 pounds	per cent..	33½
Density of juice, 10.7 B.		
Glucose	per cent..	5.83
Sucrose	do....	8.84

Samples of the canes taken from the silo on January 9 were sent to the Hutchinson Sugar Works, to the State Agricultural college, and to the State University for analysis.

On January 12, Mr. J. C. Hart, of the Hutchinson works, reported the following average of two analyses, crushed juice.

	Orange cane. Brix, 22°.	Link's Hybrid cane. Brix, 21.7°.
	<i>Per cent.</i>	<i>Per cent.</i>
Water	69.90	68.20
Insoluble solids	10.50	12.90
Glucose	3.45	3.20
Sucrose	12.34	12.19
Other solids	3.81	3.51
	100.00	100.00

Prof. G. H. Fallyer, professor of chemistry in the State Agricultural college, made the following report of his analyses of these canes on January 14:

	Orange cane.	Link's Hybrid cane.
Percentage of juice	44.9	45.5
Specific gravity	1.0876	1.0809
Sucrose, per cent	9.82	9.06
Glucose, per cent	6.84	6.65

Summarizing the results of these analyses as to cane sugar, we find that they stand as follows:

Date.	Variety of cane.	Variety of cane.	Name of analyst.
Oct. 15	Link's Hybrid, 11.21 per cent. sugar	Orange, 15.02 per cent. sugar	Cowgill.
Nov. 15	Link's Hybrid, 13.02 per cent. sugar	Orange, 10.72 per cent. sugar	Cowgill.
Nov. 29	Link's Hybrid, 12.26 per cent. sugar	Orange, 9.45 per cent. sugar	Cowgill.
Dec. 26	Link's Hybrid, 12.93 per cent. sugar	Orange, 11.69 per cent. sugar	Cowgill.
Jan. 4	Link's Hybrid, 15.25 per cent. sugar		Swenson.
Jan. 5		Orange, 14.8 per cent. sugar	Hart.
Jan. 7		Orange, 14.0 per cent. sugar	Hart.
Jan. 9	Link's Hybrid, 9.73 per cent. sugar	Orange, 8.84 per cent. sugar	Scorell.
Jan. 12	Link's Hybrid, 12.19 per cent. sugar	Orange, 12.34 per cent. sugar	Hart.
Jan. 14	Link's Hybrid, 9.06 per cent. sugar	Orange, 9.82 per cent. sugar	Fallyer.
Jan. 24		Orange, 10.85 per cent. sugar	Cowgill.
Jan. 29	Link's Hybrid, 11.40 per cent. sugar		Cowgill.

It should be remarked that the samples taken from the silo, January 9, were those which had been most exposed to the action of the sun and wind on account of the frequent opening of the silo. This may account for the great depreciation shown by the analysis of these samples.

The juice obtained on January 24 from the Early Orange cane was defecated with milk of lime, boiled, skimmed, and settled, and reduced to semi-sirup, 17° B., hot, in the usual way in open fire pan. It was then taken into a small vacuum pan and boiled to nearly the crystallizing point by Mr. Frank Stroback, an experienced sugar-boiler. It was then drawn off and set away in a warm place, and is crystallizing into a fine melada.

The juice obtained on January 29 from the Link's Hybrid cane was treated in a manner precisely similar to that above described for the Early Orange, except that it was "boiled to grain" in the vacuum pan by Mr. Stroback. This was effected as fol-

lows: Ten quarts of semi-sirup were first introduced, and boiled in *vacuo* to the crystallizing density. A pint of cold semi-sirup was then added, and the contents of the pan again reduced to the crystallizing density. The process of adding a pint of semi-sirup and reducing to the crystallizing density was repeated until the boiling was complete. After a few of these additions had been made, a slight turbidity of the sirup was observed. On placing the sirup now under a microscope and examining it by transmitted light, the turbidity was seen to result from countless microscopic crystals of sugar. The subsequent additions of semi-sirup fed these minute crystals, and they continued to grow in size as long as the operation was continued.

It is well known to sugar-boilers that it is impossible to crystallize in the pan the sugar from very poor juices. The success, therefore, of this last experiment abundantly verifies the results of the chemical analysis, which showed that this Link's Hybrid cane contained on the 29th of January very nearly the same percentage of sugar as when put away on the 15th of October. Mr. Stroback states that the crystallization was as easily produced as at any time during the working season of 1884.

It is therefore fully established that some varieties of sorghum cane can be preserved in an inexpensive way without impairment of the sugar until the last of January. It is desirable that the experiment be extended to other of the late varieties, notably the Honduras, which yields 15 tons to 30 tons per acre, but does not perfect its sugar during the regular fall working season.

CENTRAL AND AUXILIARY FACTORIES—SIZE OF FACTORIES.

The complete sugar factory is an expensive establishment, and while most of the work of operating it can be performed by laboring men of ordinary intelligence, there will be required in each of such factories, whether large or small, at least two men whose attainments will command liberal compensation. These are the chemist, or the superintendent with a cheaper chemist for an assistant, and the sugar-boiler. Good business management is of course also necessary to success. The chemist and the sugar-boiler can preside over a large as well as over a small factory. Moreover, many of the labors of the factory can be performed with no fewer men in a small than in a large factory. It will therefore be cheaper to work a given amount of cane and to turn out a given amount of product in large than in small factories. The limit, however, beyond which experience so far does not warrant manufacturers to go is believed to be at a capacity of about 270 tons of cleaned cane per day.

In order to use to the best advantage the services of the specialists of the business, it has been proposed to establish at convenient places auxiliary factories which shall carry the processes so far as to prepare sirup for the strike-pan. This sirup will be stored in suitable tanks or cisterns and worked for sugar after the close of the season for handling cane. In this way the working season for the central factory may be prolonged to occupy almost the entire year. The auxiliary factories will cost about half or two-thirds as much as the complete factory, capable of taking care of the same amount of cane. As thus arranged, the central factory will, in addition to its own regular season's work, take care of the sirup from two or three of these sirup factories.

It will doubtless be found economical to provide the central factory with sugar apparatus of two or three times the capacity required to take care of its own sirup, thereby increasing the number of auxiliaries which may be made dependent upon it. It must not be inferred from what is here said that the sugar factory can make sugar from ordinary sorghum molasses. The auxiliaries will necessarily be under the supervision of the central factory, and the value of its sirups will depend upon the proper execution of the processes of manufacture. The sirups from the auxiliaries may be transported to the central factory in tank cars or by pipe lines.

HOW FAR MAY CANE BE HAULED?

The price paid for cane delivered at the sugar factory has heretofore been \$2 per ton. It needs only to be stated that long hauls by wagon would cost too much to leave any profit to the farmer at this price. It is doubtful whether the farmer who lives more than 3 miles from the factory can afford to raise cane unless he can transport it most of the way by rail. Again, the factory will easily obtain all it can work from farmers whose distance does not exceed 2 miles, and will prefer to patronize these on account of the greater regularity with which they can deliver their crops, as well as the greater facility with which the supervision of the factory may be extended. Farmers living on a line of railroad may be able to ship their cane on such favorable terms as to avail themselves of the market at the factory. In Cuba and in some parts of Louisiana, light railroads are constructed where the distance is too great for hauling on ordinary roads. On these a team hauls about 13 tons at a load.

The system of central and auxiliary factories seems, however, to offer the best solution for the problem of distance.

CAN THE FARMER MAKE HIS OWN SUGAR FROM SORGHUM?

Several experimenters have sought to answer this question in a practical way. The developments of the last few years have clearly established the fact that the cane crusher has had its day. Hereafter the juice will be extracted by the process of diffusion, whereby at least double the yield possible with crushers is obtained, at the same time giving a juice which may be readily treated.

Mr. H. A. Hughes, of Rio Grande, N. J., has been experimenting with a small diffusion battery, and has this season worked 80 acres of sorghum with a battery whose capacity is 25 tons per day. I have not received Mr. Hughes' official report, but the results claimed are fully as favorable as those obtained at Fort Scott. His report will be looked for with interest.

Messrs. Densmore Brothers, of Red Wing, Minn., had an evaporating apparatus at Fort Scott during a part of the present season, and made

small amounts of sugar from the diffusion juice of the factory. They have furnished the following report, which will be of interest to those studying this part of the subject:

DENSMORES' REPORT.

The John F. Porter steam evaporator deserves special notice in this report. It can be safely and economically employed by every manufacturer of sorghum sirup and sugar. The line of operation employed in this evaporator is that of a shallow body of juice having a continuous flow forward among and over the pipes of steam-heated coils while being purified and concentrated.

The evaporator is composed of two pans or compartments, each of which is provided with a coil of copper pipe. By reason of a peculiar but simple method of applying steam to these coils, the development and throwing out of scum and impurities is begun as soon as the juice enters the evaporator, and is kept up until the juice is thoroughly purged of all impurity. The scum collects along one side of each pan, and within an average distance of 8 inches from the point where it was developed, and is removed from the pan as required by a simple and effective arrangement of skimmers.

While purification has been in progress the juice has been concentrated to a heavy semi-sirup, which is then finished to the desired density.

The line of operation is continuous and uninterrupted, the juice being admitted to and the finished product escaping from the evaporator in a continuous stream.

During the month of September last one of the largest of these evaporators was set up and operated at the Parkinson Sugar Works, Fort Scott, Kans., by the manufacturers for the purpose of investigating the adaptation of the principle therein employed to the manufacture of sugar, and with a special inquiry as to the per cent. or amount of inversion of sugar which it might cause.

Four runs or tests were made with this question in view, and the results—given in ratio of glucose to sucrose—were as follows:

Test No. 1.—Juice.....	1	of glucose to 3.24 of sucrose.
Finished product	1	“ 3.05 “
Test No. 2.—Juice.....	1	“ 3.29 “
Finished product	1	“ 3.27 “
Test No. 3.—Juice.....	1	“ 3.35 “
Finished product	1	“ 3.36 “
Test No. 4.—Juice.....	1	“ 3.60 “
Finished product	1	“ 3.53 “

Deductions from these results show as follows: In the first test, a loss by inversion of a little over 1 per cent.; in the second and third tests there was practically no loss, and in the fourth test a loss of less than a third of 1 per cent. The average loss on the four tests was less than three-eighths of 1 per cent. Practically, this process causes no inversion of the sucrose of the juices.

To the wants of the sirup manufacturer, the Porter evaporator is fully adapted in every essential and particular necessary to success. It works rapidly and produces a sirup of bright color and best quality. It is easily operated, and the line of operation is wholly within the control of the operator, whether working for sirup or sugar.

Mr. A. A. Denton made some experiments in air evaporation at the Sterling Sirup Works, and has furnished the following report of his apparatus and operations:

DENTON'S REPORT.

The Sterling Sirup Works have made careful tests of two forms of air-evaporating apparatus in manufacturing sirup this season, and believe the results are of impor-

tance to the cane industry, as they show that a cheap and easily-managed apparatus for evaporating at a low temperature, suited to the use of thousands of small factories, may be found in machines for drying or evaporating semi-sirup by hot air; and the method seems peculiarly adapted to the dry air of the Western States and Territories.

The first form of apparatus we used consisted of a liquid-carrier, which had 322 square feet of surface, inclosed in a box or case 3 feet wide by 2 feet, and 14 feet high, placed upon a square tank which held 300 gallons of sirup. The liquid-carrier passed continuously through the sirup in the tank, and its 322 square feet of surface were kept uniformly wet with sirup in thin films by the adhesion of sirup to the surfaces. A fan forced a blast of air through all the surfaces of the liquid-carrier. Hot sirup from the finishing pan was run into the tank, and was immediately spread over the 322 square feet of surface on the liquid-carrier by the motion of the liquid-carrier, where it came in contact with the current of air. The result was that considerable water escaped from the hot sirup in the form of steam, instead of condensing in the sirup, as it does when hot sirup is cooled in the ordinary way, and this increased the density of the sirup. The blast of air also absorbed and carried off considerable water from the sirup, and the density of the sirup was thus increased three or four degrees by the Baumé saccharometer. This was equivalent to boiling the sirup to greater density without the injury caused by the excessive heat necessary in boiling heavy sirup. The sooner sirup is removed from the heat of the finishing pan the better it is, and the sooner hot sirup is cooled the better it is, for finished sirup is hot enough to be injured by the heat it contains after it has left the finishing pan. The output of the Sterling Sirup Works is 2 to 3 barrels per hour, and in previous years we have had trouble and loss in cooling that quantity of sirup in steady day and night runs. The above-described apparatus cools hot sirup in large quantities, and also increases its density quickly and perfectly. It reduced the temperature of 100 gallons of boiling sirup from 236 degrees to 110 degrees in five minutes.

In boiling sirup we usually boil until the sirup has a density while hot of 35 to 36 degrees, as tested by the Baumé saccharometer, but after testing this apparatus we boiled only to 30 degrees, and then reduced it to the proper density by leaving it in this apparatus exposed to the blast of air until it becomes as dense as if it had been boiled to 36 degrees and had then been cooled in the ordinary way. We regard it as an established fact, that sirup at 30 Baumé can be evaporated on large surfaces by air to any density required, and also that the color and flavor of the sirup are better than when exposed longer to the high heat of the finishing pan. By allowing the sirup to remain for some time in this apparatus the sirup was evaporated or dried by the current of air to such density that it was impossible to draw the sirup from the tank through a 2-inch outlet until it had been diluted. All the sirup made this season from 700 acres of cane was cooled ready to barrel and was finished from densities varying from 30 Baumé to 36 Baumé by air evaporation in this apparatus. We next built an apparatus on the same plan as the above-described apparatus, except that it had no fan to cause a current of air; the current of air was caused by heating the air in a furnace, as is done in hot-air fruit evaporators. Hot air evaporates water much more rapidly than cold air, and in operating on thin or dilute sweet liquids it is necessary to heat the air above the fermenting point—above the point where air has chemical action on the liquid. This is shown by drying fruit in air at summer temperature; the product is the inferior sun-dried fruit, because the air has acted chemically on the saccharine liquid in the fruit; but when fruit is dried by hot air, as in the modern fruit-evaporators, the product is perfect, because hot air has no chemical action on the sweet liquid in the fruit. This hot-air apparatus had 273 square feet of surface covered with semi-sirup in thin films, and exposed to a current of hot air which absorbed and carried off the water of the sirup. In this apparatus cane juice which had been boiled until the scum was white and free from green color was evaporated

to heavy sirup by hot air. The cane juice was boiled to a density of from 20 to 25 degrees Baumé, according to the quality of the juice, and as was necessary to clarify the juice, and only boiled as long as it was necessary to skim the boiling juice. It was then dried, or evaporated by hot air, at a temperature of 130 to 140 degrees, until it became dense sirup. It is probable that it would have been better to have had a temperature of 140 to 180 degrees, which is the best temperature for evaporating fruit by hot air, and which is the usual temperature in vacuum-pan boiling. In the cold-air apparatus it was necessary to boil the juice until it had such density that air at summer temperature would not act chemically upon the sirup or ferment it, and then finish the evaporation by air at ordinary temperature.

In the hot-air apparatus it was necessary to boil the juice only long enough to clarify it, and then finish the evaporation by air heated above the point of chemical action or fermentation. To illustrate this point: Ordinary sirup may be exposed to air at summer temperature without change or fermentation, while a dilute sweet liquid exposed to air at summer temperature would be chemically changed; but a dilute sweet liquid exposed to air heated to 150 degrees, which is the scalding-point, would not ferment—it would evaporate to sirup.

This hot-air apparatus had 273 square feet of surface, inclosed in a box 3 by 2 feet and 6 feet high. At a temperature of 140 degrees it evaporated 1 pound of water per hour from each square foot of surface—that is, it evaporated 273 pounds of water per hour at 140 degrees. A gallon of cane juice weighs 8.8 pounds. Reducing 7 gallons of cane juice, or 61.6 pounds of juice, to 1 gallon of heavy sirup at sugar density weighing 13 pounds to the gallon, requires the evaporation of 48.6 pounds of water for each gallon of sirup. Where the evaporation from cane juice to heavy sirup is entirely performed by hot air, the hot-air apparatus gives 5½ gallons of sirup, weighing 13 pounds to the gallon, per hour, as the product of the evaporation from 273 square feet of surface in a current of air at 140 degrees. When cane juice is boiled to a density of 20 to 25 degrees Baumé in order to clarify it, and the hot-air apparatus is only required to finish the evaporation, it produces from 10 to 15 gallons of heavy sirup per hour, for the greater part of the evaporation has been performed by boiling.

The hot-air apparatus above described is of a size and capacity suited to a two-horse cane-mill. It would finish the semi-sirup produced by such a mill to heavy sirup, using a temperature of 140 degrees instead of 240 degrees, which is required in finishing heavy sirup by boiling.

The principle of the air-evaporating apparatus is, that evaporation is as rapid from large surfaces exposed to air at comparatively low temperature as from small surfaces intensely heated, and that in evaporating dilute sweet liquids it is necessary to heat the air above the point of chemical action upon the liquid. Solid substances have large quantities of water removed from them by exposing large surfaces to the evaporating action of the air. A bushel of apples weighing 50 pounds is reduced by hot air to 6 pounds of perfect product. The same can be done with liquids under similar conditions. As a result of these experiments we intend to build hot-air apparatus large enough to reduce all our semi-sirup to sirup by hot air next season.

If the question be asked, "Can the farmer *profitably* make his own sugar?" i. e., make sugar for his own use in a small way, I apprehend that the answer should be much the same as would be given to the question, "Can the farmer profitably make his own woollen goods or his own flour?" If, indeed, I have succeeded in the preceding pages in conveying an adequate idea of what sugar-making is, I apprehend that my readers will omit to ask the questions about manufacturing in a very small way.

The farmer who is so fortunate as to be near a sugar factory can do much better than to erect and try to operate sugar machinery on a

small scale. An acre of good sorghum delivered at the factory will pay for a barrel of nice nearly-white sugar. The farmer who is not so fortunately situated will probably try to induce some company to erect a factory near him, or will join with his neighbors in forming a company for the purpose of building a factory as soon as the skilled labor necessary for its operation can be secured, thereby providing not only his own sugar from his own soil, but at the same time a sure and steady market for the most certain and profitable crop he can raise.

SUGAR REFINERIES.

The sugar produced by the processes herein described is light, but not white, in color. Its sweetening power is not surpassed by any raw sugar, and its taste is very agreeable. The demand of the age is, however, for the best possible goods, and sorghum sugar must be refined to the purest whiteness, and made into the various conditions demanded by the market.

To do this requires the work of the sugar refinery. The largest of the central factories soon to be erected will doubtless be provided with refining facilities, and when located at convenient shipping centers will be developed into large refineries as rapidly as the raw sugar can be obtained to give them work.

CONCLUSION.

There seems to be no doubt but that there is here developed an industry of vast importance to our State and nation. For the year ending June 30, 1886, there was consumed in the United States foreign grown and manufactured sugar amounting to 2,689,881,765 pounds.* If two thousand new sugar factories were at once erected, and each should produce an annual product of one and a quarter million pounds of sugar, they would not supply the place of the sugars now imported.

The annual consumption of sugar per capita in the United States is about 56 pounds. The population of Kansas may be taken as 1,500,000. These people consume each year $56 \times 1,500,000 = 84,000,000$ pounds of sugar. It will be safe to say that the annual average product of the factories will not exceed 1,500,000 pounds, so that fifty-six factories will be required to supply the sugar consumed by the present population of Kansas, and for which they pay over \$5,000,000 annually.

Processes whereby sugar can be made at a profit from sorghum have been worked out. These are far from perfect, but present developments give promise of others in the near future, and will enable us to produce our own sugar on our soil, with the labor of our people. Those who invest in the new industry will be cautious about experimenting with unknown conditions. Kansas is therefore likely to lead in the development, and become the first Northern sugar State.

*Address of Dr. H. W. Wiley before the Chemical Society, December 9, 1886.

LETTERS PATENT GRANTED TO M. SWENSON.

UNITED STATES DEPARTMENT OF AGRICULTURE,
COMMISSIONER'S OFFICE,
Washington, D. C., December 10, 1887.

SIR: In response to the resolution of the Senate of the 7th instant, directing me to inform the Senate whether any person in the employ of this Department has applied for or obtained a patent on any process connected with certain experiments in the manufacture of sugar from sorghum, conducted under the auspices of the Government, I have the honor to make the following statement of facts:

For the fiscal year 1886-'87 Congress made an appropriation of \$94,000 for "continuing and concluding experiments in the manufacture of sugar by the diffusion and saturation process, from sorghum and sugar-cane." By virtue of this appropriation the Commissioner appointed, under date of July 19, 1886, Mr. Magnus Swenson "an agent of this Department to superintend, under the direction of the chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans."

In his report to me, under date of December 21, 1886, Professor Wiley, the chief chemist of this Department, in detailing the experiments above alluded to, stated that an acidity existed in the diffusion bath, causing a conversion of a portion of sucrose (sugar) into glucose, and that several experiments had been made to correct this acidity. Among those experiments was one in which he added "freshly precipitated carbonate of lime to the extraction bottle," a method which he states was suggested by Professor Swenson. At the close of these experiments, November 15, 1886, Mr. Swenson's service ceased. On April 27, 1887, he was again appointed "superintendent of sugar experiments at Fort Scott, Kans.," which position he now holds. On October 21, 1887, I was informed that Professor Swenson was seeking a patent for the process which he had suggested as above stated, and while in the line of his duty and which had been tried in a public experiment with the people's money and for the benefit of the country. On that date I filed with the Commissioner of Patents my protest against any action on the part of his office by which Professor Swenson, as an individual, should reap the benefit of this experiment. In answer to that letter I received a communication from the Commissioner of Patents,

under date of October 26, stating that Professor Swenson had been allowed letters patent on the process, under date of October 11, 1837. In that patent the following claims were allowed to Professor Swenson :

(1) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath a carbonate of the alkaline earths, substantially as set forth.

(2) As an improvement in the diffusion process of making sugar, the mode herein described of preventing the invertive action of the organic acids in the cane chips upon the sugar during the process of extraction, said mode consisting in adding to the diffusion bath calcium carbonate, substantially as set forth.

The application for this patent was filed on December 29, 1886, after Professor Swenson's employment by the Government had ceased, but the nature of the claims is so closely allied to the experiment made with carbonate of lime, heretofore alluded to, that it seems to leave no doubt that Professor Swenson intended to cover in his patent the suggestion which he made in the line of his duty, which was adopted during his employment, and which amounted only to an improvement in a process which had been conceived, planned, and was then being perfected by the Government of the United States.

I deem it proper to add that I have had an exhaustive search made of judicial decisions and legal opinions bearing upon the validity of a patent granted under these circumstances, and that I have become convinced that the state of the art, and the fact of Mr. Swenson's appointment and employment by this Department, will affect the validity of his claim, and that I have therefore called the attention of the Attorney-General to all the facts in the case and suggested to him the institution of a suit looking to a perpetual injunction to restrain Professor Swenson from making any use of this patent.

As bearing upon this case, I beg respectfully to inclose, as an appendix to this communication, certain citations and memoranda for the information of the Senate, and in this connection I beg also to recommend such immediate action on the part of the legislative branch of the Government as will enable the Attorney-General, if he has not now sufficient authority, to institute a suit looking to the cancellation of the patent in question.

Very respectfully, your obedient servant,

NORMAN J. COLMAN,
Commissioner of Agriculture.

HON. JOHN J. INGALLS,
President pro tempore United States Senate.

[Copy of statement of facts submitted to the Attorney-General for his information by the Commissioner of Agriculture.]

Letters Patent, No. 371528, issued to Magnus Swenson. Manufacture of sugar.

STATEMENT OF FACTS.

The Department of Agriculture directed its attention to the manufacture of sugar from maize and sorghum cane in the year 1877, and since that time has continuously been engaged in investigations and experiments for the purpose of discovering a process that would extract the sugar from these canes in a commercially successful manner. These experiments have been carried on by direct authorization of Congress.

The first session of the Forty-seventh Congress appropriated, "For experiments in the manufacture of sugar from sorghum, beets, and other sugar-producing plants, twenty-five thousand dollars." (Stat. L., vol. 22, p. 91.)

The same Congress at its second session appropriated \$16,000 (vol. 22, p. 410); the Forty-eighth Congress at its first session appropriated \$50,000 (vol. 23, p. 38), and at its second session, \$40,000 (vol. 23, p. 354) for the same purpose. In 1883 the chemist of the Department conceived the idea of adapting the "diffusion process," successfully used in Europe in the manufacture of beet sugar, to the extraction of sugar from sorghum and maize cane. The results of the experiments carried on in this direction during the year 1883 are continued in special Bulletins Nos. 2 and 3, issued by the Chemical Division of the Department in 1884.

Further investigations were made during the year 1884, and a chemist from the Chemical Division was sent to Europe to study the "diffusion process" as practiced there and the machinery used in its application. The results of the work for this year are fully set out in Bulletin No. 5. Bulletin No. 6 contains a record of the work for the year 1885.

In the fall of 1885 Professor Wiley, chemist of the Department, was directed to proceed to Europe to study the "diffusion process." Bulletin No. 8 gives the result of his visit there and conclusions reached as to the proper adaptation of process and machinery to manufacture sugar in this country from sorghum cane by the "diffusion process."

As a result of the investigations and experiments brought down to 1886, this Department felt convinced that it had reached a satisfactory solution of sugar manufacture, as applied to sorghum, and that it had secured a successful method and devised suitable machinery to establish this work as one of the commercial industries of the country. To test the process and the machinery devised on a commercial scale, and for the purpose of perfecting by experiments any defect that might arise either in the chemical progress of the process or mechanical arrangement of the machinery, the Department received from Congress an appropriation for these purposes.

On June 30, 1886, there was appropriated as follows: "For purchase, erection, transportation, and operation of machinery, and necessary traveling within the United States, and other expenses in continuing and concluding experiments in the manufacture of sugar, by the 'diffusion and saturation processes,' from sorghum and sugar cane, so much thereof as may be necessary to be immediately available, \$94,000." (Stat. L., vol. 23, p. 101.)

Under this act of Congress the Commissioner of Agriculture on the 19th of July, 1886, employed and appointed one Magnus Swenson to "superintend, under the direction of the chemist, the experiments in the manufacture of sugar from sorghum at Fort Scott, Kans," at a salary of \$2,400 per annum, during the continuance of the experiments. A copy of this appointment is hereto appended. (Exhibit A.)

The experiments carried on under the foregoing act of Congress last mentioned are set out in detail in Bulletin No. 14, a copy of which is appended. (Exhibit B.)

In the course of these experiments a difficulty was met with, described on page 28 of Exhibit B, namely, an acidity in the diffusion battery, which caused an inversion

of a portion of sucrose into glucose, thereby diminishing the amount of sugar that should be obtained. On the same page are detailed the experiments made to overcome this defect. Experiment No. 4, "the addition of freshly precipitated carbonate of lime to the 'extraction bottle,'" was suggested by Mr. Swenson, the superintendent of the experiments, under the foregoing employment. Comments on the result of this experiment will be found on pages 32 and 33 of Bull. 16.

Experiments at Fort Scott, Kans., were discontinued on November 15, 1886, and the service of Mr. Swenson as agent of this Department ceased on that day.

On December 29, 1886, Mr. Swenson filed an application for letters patent for an improvement in the manufacture of sugar, and on October 11, 1887, letters patent No. 371528 were issued to him.

This patent is for the use of carbonate of lime and carbonates of other alkaline earths in the diffusion bath to prevent the invertive action of organic acids during the process of extraction. It is simply a patent for experiment No. 4, as made at Fort Scott, Kans., by this Department, and set out on page 28 of Bull. 16.

I am informed that Mr. Swenson is now threatening to prosecute all persons who shall use the method described and covered by his patent, and this Department, still being engaged in experimentation for the manufacture of sugar, will be liable to Mr. Swenson in damages for using a process discovered by itself, if the patent aforesaid is rightfully the property of Mr. Swenson.

II.

CONDITION OF THE ART.

The aforesaid patent is for the use of carbonate of the alkaline earths to neutralize organic acids present in saccharine solutions, and thus prevent inversion of sucrose into glucose. This is not new, and has been known to those engaged in the art of manufacture of sugar for years, and allusions are to be met with to its use in works describing this art, and patents have been issued for this same means for neutralizing acidity in saccharine solutions in England. A brief reference to some of these will be made.

In a work entitled "Sugar Growing and Refining," by Wigner and Harland, published in London in 1882, the following allusions are made pertinent to this part of the art.

On page 185, in describing the diffusion process, it says:

"In order to insure the solidification in the tissues of the soluble substance injurious to the sugar, especially of pectine, which is not coagulated by hot water alone, *lime or some other suitable agent* may be added to the water or liquor."

On page 504 of the same work, in speaking of the alum process, it says:

"After the separation of the alum it is possible to *neutralize the acid liquor* with *chalk* (carbonate of lime) only, and this has been done on a large scale for a considerable time. The use of chalk has an advantage over lime in that should an *excess* be added it does no harm to the sirup beyond simply *increasing the insoluble deposit in the filters*."

A description of the identical advantage claimed by Mr. Swenson in his patent, lines 52 to 58, * * * "it is possible to neutralize the acid liquor with some other alkaline body instead of lime; among other substances which have been tried for this purpose are ammonia, carbonate of ammonia, baryta, carbonate of baryta, strontia, carbonate of strontia, magnesia, carbonate of magnesia." Those are the carbonates of alkaline earths mentioned in the patent, lines 58 to 63.

In a pamphlet published in Cincinnati in 1876, entitled "Extraction du Jus Sucré des Plantes saccharifères, par Diffusion," the author of which is G. Bouscarel, is found, on page 2, a description of the alleged improvement patented by Swenson, and it speaks of the addition of chalk (carbonate of lime) to either the water of the diffusion battery or to the pulp of the cane itself before it goes into the battery.

The following is a translation of the paragraph referred to:

"The solidification of the albumen, pectine, and other elements injurious to the sugar being made in the tissue of the pulp itself by the *addition* of a *proper* quantity of *chalk*, either to the water of alimentation or to the pulp itself before its introduction into the macerators."

Of the English patents that have been issued may be noted the following: In 1813 No. 3754, to one Howard, the use of alum, lime, and chalk.

In 1874, No. 1736, to Johnson, the use of alkaline carbonates prior to treatment of the sugar with alcohol.

In 1874, No. 1989, to James Duncan, the neutralization of the free acids arising in saccharine solutions by means of carbonate of lime.

III.

From the foregoing statements the following conclusions may be drawn:

(1) That the above patent is held by Mr. Swenson in trust for the use and benefit of the Government and its citizens, the discovery patented having been made by him while specially employed in experimentation, and under an implied contract granting to the Government all property in the results of such experimentation.

(2) That the thing patented was a suggestion made by an employé specially employed for the purpose, and which only amounted to the curing of a defect in a part of a process already planned in its entirety by another, and which of itself was not a complete invention, and which suggestion would belong to the inventor of the process under whom he was working.

(3) That the patent is invalid in that the thing patented is not *new*.

Under the first head it is sufficient to say that Congress having authorized the making of these sugar experiments at public expense, they are made for the benefit of the public at large, and the results that spring from them become the property of the Government, to the free use of which all citizens are equally entitled. Persons employed in the carrying on of such experiments, so authorized, by the acceptance of the employment waive all personal right to any discoveries they may make in the course of their employment, and by implication contract that such discoveries shall become the property of the Government. It would be incompatible with the object of the act of Congress authorizing the making of experiments, that any personal property to discoveries made by person employed under the law should be retained by them, for, if so, then the end had in view, the general benefit of the public, would be destroyed, and public moneys would be expended merely to enable private persons to make discoveries for their own personal use and advantage, and not for the general welfare of the people. Congress would be granting public moneys for private use, and this it can not constitutionally do.

While there are no adjudicated cases bearing upon the right of a person employed by the Government to make experiments to discoveries made by him in the course of experiments, there is a dictum by Justice Field, in the case of *United States v. Burns*, 12 Wallace, page 246, where he says: "If an officer in the military service, *not especially employed to make experiments with a view to suggested improvements*, devises a valuable improvement, he is entitled to the benefit of it, and to letters patent," etc.

This may be held to imply the *converse*, that where such officer was employed to experiment he would *not* be entitled to patent his improvement.

Under the second head, it is sufficient to state that the suggestion made by Mr. Swenson makes a case on all fours with the general doctrine laid down in the leading case of *Agawam v. Woolen Company* (7 Wallace, 583) on the relations between employers and employés, and that such improvement as he suggested would be for the use and benefit of his employer.

The doctrine is thus stated in the opinion by Justice Clifford:

"Persons employed, as much as employers, are entitled to their own independent inventions, but where the employer has conceived the plan of an invention and is en-

gaged in experiments to perfect it, no suggestions from an *employé*, not amounting to a new method or arrangement, which in itself is a complete invention, is sufficient to deprive the employer of the exclusive property in the perfected improvements. But where the suggestions go to make up a perfect and complete machine, embracing the substance of all that is embodied in the patent subsequently issued to the party to whom the suggestions were made, the patent is invalid, because the real invention or discovery belongs to another," and cases cited.

Under the third head it is unnecessary to comment, for the thing patented not being new, the patent is invalid.

IV.

REMEDY.

The possession by Mr. Swenson of this patent has a serious and damaging effect on the progress of the manufacture of sugar from sorghum cane in this country. It is a cloud on the title of the people of this country to make use of a discovery which the Government has at public expense made. Congress, in authorizing the expending of \$225,000 to promote this manufacture, was mindful of its great importance and the benefits to arise from utilizing sorghum cane, which could be grown over an immense area of this country, and make valuable thousands of acres of land, and at the same time cause the production of the home supply of sugar.

This new enterprise has received a damaging blow, and it is desirable that the law department of the Government should take all necessary steps to protect this enterprise, to remove the cloud that to-day prevents the free use of this manufacture as perfected by the Department of Agriculture, and secure to the people the full benefit of all its works.

It is suggested that where a patent has been improperly obtained by a person employed by the Government to carry on experiment for discoveries made in the course of the experiments, the patentee may be *restrained* by injunction from appropriating to his own use any of the rights granted by the patent. This is the view as held by Attorney-General Cushing in an opinion to be found in volume 7, *Opinions Attorneys-General*, page 656.

PART II.

EXPERIMENTS AT RIO GRANDE, N. J.

REPORT OF H. A. HUGHES.

SIR: I have the honor to present herewith my report, as superintendent of the experiments conducted at Rio Grande the past season, on the manufacture of sugar from sorghum.

The Hughes Sugar House Company is located at Rio Grande, Cape May County, N. J. The building of this company is constructed of brick and iron, 30 feet square, and fully equipped with machinery for extracting and working into merchantable products all of the sugar from 15 tons of cane per day.

The machinery consists of a cleaning and shredding apparatus, a diffusion battery, an open evaporator, vacuum pan, hot room, wagons, and centrifugal.

The cane is cut into sections, freed from leaves, sheaths, and seed tops, and passed in at once to the shredding knives. The leaves and seed tops are also separated and collected into different receptacles. All this machinery is automatic, and the capacity of the cleaning apparatus was proved to be equal to the cleaning of 44 tons in twenty-two hours. It worked without delay or repairs of any description, and the wear and tear was so slight that at the close of the season its condition appeared to be as good as when first started. All this apparatus had been thoroughly tested during the season of 1886.

The shredded cane is packed into perforated baskets and it is then ready for the diffusion battery.

This battery differs radically from those in ordinary use, and was planned in 1886. During this season its work was not perfectly satisfactory—concentration of juice being gained only at a serious loss of sugar in the waste products—but after the close of the season and when the battery was properly managed, it was proven and the tests recorded, which have shown that it can extract practically all of the sugar in the cane at an expense for evaporation of 10 per cent. only in excess of that for mill juice; this result is satisfactory, and is believed to be better than that given by any other battery. The diffusion juice from this battery

was evaporated in an open pan until one-half of its water was removed; it was then drawn into the vacuum, still further concentrated, grained in the same pan, and struck into sugar wagons in the hot room. The centrifugal machine separated the crude molasses from the raw sugar, leaving it in a condition suitable for refiners' uses. Storage tanks, settling tanks, filter presses, defecators, clarifiers, and chemicals of any kind were not used. The vacuum pan and centrifugal machine do not differ from well-known forms.

THE CROP.

Eighty acres of cane were planted for the use of the mill, and of this 7 acres were grown by neighboring farmers and the balance by the company. Varieties planted were Amber, White African, Kansas Orange, and Late Orange, from which 910 pounds sugar and 80 gallons of molasses per acre were made. In this account is included the unripe cane used in breaking in the house and all damaged cane. The tonnage far exceeded our greatest expectations. This was occasioned by carefully planting the hills closer and giving it good attention, together with favorable rains. The cost of raising the cane was \$11.62 per acre. This includes the hauling out of fertilizers and placing them upon the land, which consisted of 150 pounds muriate of potash per acre, and rotten chips from previous seasons, together with a little stable manure in spots. The cost of potash and chips is not included in the above. The cost of cutting the cane and bringing it to the factory was 45 cents per ton. We paid \$3 per day for the use of teams and farm hands, and laborers were paid \$1.25 per day.

The average yield was 16½ tons per acre. All the farmers' cane was worked and 27.38 acres of that raised by the company. Over 47 acres were left in the fields. One tract (8.43 acres) averaged 25 tons of cane per acre, from which 1,400 pounds of raw sugar and 120 gallons of molasses per acre were extracted.

Part of the field was used in breaking in the house.

The yields of the farmers' crops varied widely, the maximum being 1,970 pounds of raw sugar and 120 gallons of molasses per acre. This was made from 17 tons and 675 pounds of field cane. The term "field cane" means neither stripped nor topped. The minimum was 540 pounds of sugar and 60 gallons of molasses. All the seed used by the farmers was the same. The variations in yield were caused by the difference in cultivation. Other yields were as follows per acre:

	First.	Second.	Third.	Fourth.
Sugar..... pounds	1,970	1,560	1,444	1,254
Molasses..... gallons	120	120	80	116

The company grew this cane on shares, giving the farmers one-half the products, viz, sugar, molasses, and seed. The basis of settlement

was for raw sugar 4 cents per pound and molasses at 25 cents per gallon. Consequently the four best acres yielded—reduced to a cash basis—as follows :

	Quantity.	Amount.	Total.
Ephraim Hildrith:			
Sugar, at 4 cents.....pounds	1, 970	\$78. 80	} \$108. 80
Molasses, at 25 cents.....gallons	120	30. 00	
Joseph Richardson:			
Sugar, at 4 cents.....pounds	1, 560	62. 40	} 92. 40
Molasses, at 25 cents.....gallons	120	30. 00	
William Hollingshead:			
Sugar, at 4 cents.....pounds	1, 444	57. 76	} 77. 76
Molasses, at 25 cents.....gallons	80	20. 00	
John Brown:			
Sugar, at 4 cents.....pounds	1, 254	50. 16	} 79. 16
Molasses, at 25 cents.....gallons	116	29. 00	

This does not include the seed which has not been thrashed.

WORKING SEASON.

The company commenced breaking in its machinery on September 5 and closed on November 8, making fifty-two days. Twelve days in the commencement of the season were consumed in training men to manage the new machinery. The working season was the most unfavorable since 1880. Frost occurred in the last week in September, but did little damage. Ice one-half inch thick was found on October 15. The crop at that time was growing beautifully and the sugar tests rising rapidly, and the day following this freeze the leaves turned white and died.

At that time we were working on the Kansas Orange fields. This variety did not deteriorate for several days, but at the expiration of this time it gradually declined until October 28, when the purity of the juice was reduced so low that it did not warrant our working any longer for sugar. During this period there were several frosts.

Another effect of the ice on this variety of cane was to make it unable to withstand the repeated heavy gales of wind, which finally blew it down and broke it badly.

It was especially our desire to study the effects of frost on the different varieties, and we were fully aware that we could at any time increase our average sugar per acre by leaving this variety and working the Late Orange. After October 28 we commenced cutting on the Late Orange fields, which had withstood frost and ice in marked contrast with the other cane. This variety stood the freezes and thaws with very little change, and at the time of the closing of the house it was still up to the average of the season in purity.

The cane was worked after this date at intervals in the diffusion battery until November 22. The cane brought in at this time was frozen solidly, but the juice was in good condition. Warm weather having intervened from the 22d to the 26th the cane was sampled and tested on November 26 with the intention of making a run for sugar

on December 1. Other matters having interfered this was not carried out. There is not the slightest doubt that good sugar crystals could have been obtained until December 1.

This cane has at last been weakened by the unusually severe weather during the past week. It is falling down badly and is only fit for sirup on this date, December 7.

The sugar per acre could have been increased fully 23 per cent. on this season's work by good extraction. It must not be overlooked that the raw sugar made this season would have to be reduced from 20 to 25 per cent. in order to make it chemically pure.

Another source of loss to which I desire to call your attention is in the harvesting of the seed. The seed tops are cut off, spread on the fields to dry, stacked up, and afterwards thrashed. By this method we rarely obtain more than $1\frac{1}{2}$ bushels of seed from a ton of field cane. There is a constant loss in the field during the drying by the seed shelling out and the ravaging of birds. Field mice and rats also attack the stacks. Samples of seed tops carefully saved from these same fields show an average yield, on well developed canes, of 3 bushels per ton. If this seed could be saved it would be of sufficient value to pay the coal bill for working up the crop in this place.

In making the above statements I wish it to be distinctly understood that neither time nor expense was spared in order to make these records accurate; the house being frequently delayed in order that the records might be secured.

I believe that a ton of field cane is too uncertain a factor to be used as a standard for calculation, as it varies considerably in wet and dry weather. Wagons containing 3,000 pounds of cane, as it comes from the field, will increase to 3,400 pounds and more by being rained on. There is a variation in the weight of the cane before and after frost; also in the percentage of leaves of the large and small canes. For these reasons it is better to use clean chips prepared for the battery or an acre of ground.

It might be worth while to state that this sugar house, with slight alteration, could be made to work 25 tons per day, having frequently worked at this rate from six to eight hours.

Believing that sorghum-sugar manufacture is to be an established industry and that reports of this nature will have an attraction for the general public, I have written in this simple style and tried to avoid technicalities. Those who wish the details I refer to the reports of your chemists, Messrs. Broadbent and Edson, who, I believe, have faithfully recorded the workings of the house; also to the report of the experimental station of New Jersey, soon to be issued.

Respectfully,

H. A. HUGHES,
Superintendent.

Hon. NORMAN J. COLMAN.

Commissioner of Agriculture, Washington, D. C.

SUMMARY OF CHEMICAL WORK AT RIO GRANDE.

(Abstract of report of Hubert Edson.)

The manufacturing season at Rio Grande commenced September 5 and closed November 8. The analyses of juices were begun September 8 and continued throughout the season.

On October 15 there fell a heavy frost, one of the earliest known in Rio Grande, which completely killed all the leaves on the cane and stopped the growth of all the unripe fields. The late orange was the only variety which was not seriously injured by the frost and the cold weather following it. This hardy cane, although the frost touched it before it was matured, held its sucrose to the end of the season, even notwithstanding two slight freezes.

It will be noticed from Table III that the extraction of sugar by the battery was very poor. This arose from improper management of the battery by the men employed in the diffusion room, much sugar being thrown out with the exhausted chips from this cause.

EXPERIMENTS IN CRYSTALLIZING SUGARS.

All the sugars as first run from the centrifugal were full of "smear," and after the regular season had closed experiments were made as to the advisability of re-crystallizing the sugar, but it was found that the loss in weight was too great to make it profitable, only 8,329 pounds of re-crystallized sugars being obtained from nearly double that amount of smear sugar.

In Table VIII are found the analyses of the re-crystallized sugars.

On November 19 and 22 experiments were made with the diffusion battery to see if it was possible to obtain a better extraction than the season's work had given.

An extra cell was made and placed outside the battery. Then instead of emptying one cell of diffusion juice at a time the two heaviest juices were drawn into the outside cell. By drawing off two cells at a time two baskets of fresh chips could be immersed each time in the outside cell, and the diffusion juice be brought up within 1° Brix of the mill juice, and at the same time an excellent extraction obtained. Both the days in which these experiments were made were very cold. This, of course, made it difficult to keep the battery at a sufficiently high temperature for a proper diffusion.

In the appended table the degree Brix is all that is given, as the juices were not used:

	Chip juice.	Diffusion juice.	Exhausted chip juice.
Average degree Brix:			
November 19	15.40	14.65	1.80
November 22, a. m.	13.42	12.66	1.48
November 22, p. m.	15.18	13.79	.88

These experiments were conducted by Mr. Hughes and Dr. Neale, chemist of the New Jersey experimental station. The degrees Brix were taken by Dr. Neale and myself.

A sample of chip juice was polarized and found to contain 8.98 per cent. sucrose, with a purity of 59.27.

RESULTS OF ANALYSES.

TABLE 1.—*Analyses of juice from fresh chips.*

Number of analyses	61
	Per cent.
Mean sucrose	8.98
Mean glucose	3.24
Mean total solids (by spindle)	14.02
Sucrose:	
Maximum	12.28
Minimum	4.71
Glucose:	
Maximum	4.45
Minimum	2.07
Total solids:	
Maximum	17.80
Minimum	10.45

TABLE 2.—*Analyses of diffusion juices.*

Number of analyses	63
	Per cent.
Mean sucrose	6.93
Mean glucose	2.86
Mean total solids (spindle)	11.18
Sucrose:	
Maximum	10.02
Minimum	3.89
Glucose:	
Maximum	3.97
Minimum	1.32
Total solids:	
Maximum	14.40
Minimum	8.38

TABLE 3.—*Sirups.*

Number of analyses	55
	Per cent.
Mean sucrose	18.68
Mean glucose	8.67
Mean total solids (spindle)	32.40
Sucrose:	
Maximum	25.26
Minimum	10.78
Glucose:	
Maximum	15.70
Minimum	3.81
Total solids:	
Maximum	43.16
Minimum	19.88

TABLE 4.—*Exhausted chips.*

Number of analyses	58
	Per cent.
Mean sucrose	2.46
Mean glucose	.98
Mean total solids (spindle)	4.03

TABLE 4.—*Exhausted chips*—Continued.

Sucrose :	Per cent.
Maximum	4.23
Minimum	.81
Glucose :	
Maximum	1.62
Minimum	.30
Total solids :	
Maximum	6.64
Minimum	1.33

TABLE 5.—*Masse cuites*.

Number of analyses	6
	Per cent.
Mean sucrose	55.76
Mean glucose	23.44
Mean water	18.50
Mean ash	4.44

TABLE 6.—*Raw sugars*.

Number of analyses	14
	Per cent.
Mean sucrose	73.80
Mean glucose	13.63
Mean water	5.89
Mean ash	2.56

TABLE 7.—*Molasses*.

Number of analyses	14
	Per cent.
Mean sucrose	35.48
Mean glucose	32.20
Mean water	34.72
Mean ash	5.45

TABLE 8.—*Re-crystallized sugars*.

Number of analyses	9
	Per cent.
Mean sucrose	90.73
Mean glucose	4.63
Mean water	4.19
Mean ash	.71

(NOTE.—The analyses of *masse cuites* sugars and molasses are only partial. The complete analyses will be given in Bulletin 18.)

ESTIMATES OF COST OF SUGAR FACTORIES MADE BY MR. H. A. HUGHES.

SMALL CENTRAL SUGAR HOUSE.

Cost and summary of machinery.

One vacuum-pan, 4 feet	\$850.00
One vacuum-pump	500.00
Thirty sugar-wagons, at \$14	720.00
Two Weston centrifugals, complete with mixer, at \$350	1,700.00
Four tanks, water, sirup, dumps, and extra, at \$25	100.00
One 50 horse-power boiler	600.00
One engine, 15 horse-power	400.00
Pipe-fittings	800.00
Two boiler feed-pumps, at \$90	180.00
One water-pump	200.00
Two sirup-pumps, at \$90	180.00

Cost and summary of machinery—Continued.

Extra work, machinist two months and labor	\$520.00
Buildings	3,000.00
Freights, lights and extras	250.00
Total	9,000.00

Capacity of house per day.

Six wagons on 1,080 gallons molasses worked into <i>masse cuite</i> for an average, say 4 pounds sugar to a gallon, or	pounds.. 4,320
And 45 per cent. sirup	gallons.. 488
For 260 days, from September 1 to July 1	pounds.. 1,123,200
For 260 days, from September 1 to July 1	gallons.. 126,880

Crew, cost of manning, and cost per gallon.

Day shift:	Per day.
One fireman	\$1.50
One centrifugal	1.50
One sirup and coopering	2.50
One sugar boiler	3.00
Night shift:	
One fireman	1.50
One pan man	1.50
	11.50
Three tons soft coal, at \$2.50	7.50
	19.00
Cost per gallon	1.77
Twenty-five gallons for 1 ton field cane	cents.. 44½

SMALL AUXILIARY PLANTATION HOUSE.

One diffusion battery, 50 to 75 tons, complete	\$5,600.00
Cutting and cleaning apparatus	800.00
One double effect	2,500.00
Two juice-pumps, at \$90	180.00
Seven small tanks	100.00
One large tank	25.00
Engine, 8 horse-power	200.00
Boilers, 100 horse-power	1,000.00
Two boiler feed-pumps, at \$125	250.00
One water-pump	250.00
One hot-water pump	125.00
Pipe-fittings	500.00
Building one-story shed	1,000.00
Labor, freight, and incidentals	800.00
Total	13,330.00

Capacity per day.

Lowest estimate, 50 tons field cane; 25 gallons molasses, 45 to 56 per cent. test for each ton field cane worked; 25 gallons for each ton $\times 50 = 1,250$ per day for eighty days = 100,000 gallons, or 4 acres of ordinary cane per acre for each day; or 320 acres per season of eighty days.

Three such plants would supply 300,000 gallons in a working season.

Crew, cost of manufacture, and cost per ton.

One man throwing cane on carrier	\$1.25
One man on seed topper	1.25
One man filling baskets	1.25
One man on eleventh cell	1.25
One man hanging on baskets	1.25
One man center	1.25
One man bagasse	1.25
One man double effect	1.50
One man firing	1.50
One man driving away seed and leaves	1.25
Total 10 men	13.00
One horse on cart	1.00
	<u>14.00 × 2 = \$28.00</u>
Labor	28.00
Coal, 5 tons, at \$2.50	12.50
	<u>40.50</u>

Or 80.1 cents per ton for labor, etc.

RECAPITULATION.

Capital invested, small central house	\$9,000
Capital invested, three small auxiliaries, \$13,300	39,990
Total	48,990

Amount of cane worked, 150 tons for eighty days	<u>Tons.</u> 12,000
---	------------------------

Product.

12,000 tons, yielding 25 gallons molasses each	gallons..	300,000
300,000 gallons molasses, yielding 4 pounds sugar each	pounds..	1,200,000
And 45 per cent. molasses	gallons..	135,000
1,200,000 pounds, at 4 cents		<u>\$48,000</u>
135,000 gallons, at 20 cents		27,000
18,000 bushels seed, at 40 cents		7,200
Total		<u>82,200</u>

Cost of production.

	<u>Cents.</u>
Auxiliary house, per ton	80.01
Central house, per ton	44.25
	<u>124.26</u>
Cost of packages, per ton	30.00
	<u>154.26 × 12,000 = \$18,511</u>

Farmers' half, \$41,100 or 3.43 per ton; the company's half, \$41,100, less \$18,511, \$22,589 for interest, insurance, superintendence, etc.

In working 1,000 tons a day there should be ten 100 to 175 ton batteries and a large central house. Auxiliary houses of this size would cost complete about \$20,000 each and the central house would cost without bone black \$90,000. There would also be a corresponding reduction in working expenses.

PART III.

EXPERIMENTS AT LAWRENCE, LA.

The Department of Agriculture having determined to continue the experiments in the manufacture of sugar by diffusion in Louisiana, Mr. E. C. Barthelemy, of New Orleans, was appointed general superintendent of the work January 27, 1887.

Following is a copy of the order assigning him to this duty:

JANUARY 27, 1887.

E. C. Barthelemy, of Louisiana, is hereby appointed general superintendent of the diffusion experiments to be conducted in Louisiana by this Department.

NORMAN J. COLMAN,
Commissioner.

The following instructions were sent with the order to Mr. Barthelemy:

JANUARY 27, 1887.

DEAR SIR: I inclose you herewith your formal appointment as general superintendent of the experiments in diffusion which are to be made in Louisiana next autumn.

At present your instructions will be of a simple nature.

The contract for the building of the machinery has been awarded to the Colwell Iron Works of New York, the lowest responsible home bidders.

This company has also taken the contract of erecting the battery in Louisiana and putting it in order for use.

First of all you will consult with prominent sugar planters and others interested in the matter in respect of the best place for locating this experimental machinery. Keep in view that good double-effect and strike pans and convenient crystallizing rooms, etc., must be had.

I expect to visit Louisiana early in March, and by that time you will have secured such information as will enable me to decide upon the location at once.

Immediately thereafter the machinery and building material now at the "Hermitage" plantation will be transferred to the new quarters, and then the apparatus now at Fort Scott, which is to be used in Louisiana, will be secured. The details of this work I will send you later. As soon as you enter upon the performance of your duties, February 1, you will proceed to Judge Emil Rost's plantation and make a careful study of the machinery on hand, and submit to me, at your earliest possible convenience, a full report thereon, and add thereto your own judgment concerning the suitability of the place for the proposed experiments.

It is my earnest wish that all persons interested in the success of the sugar industry should heartily co-operate in this work.

Very respectfully,

NORMAN J. COLMAN,
Commissioner.

E. C. BARTHELEMY,
New Orleans, La.

On February 18, 1887, the following additional instructions were sent to Mr. Barthelemy:

First of all, however, I desire to secure a comparative test of diffusion with milling. When all is in readiness for work, only a few days will be required to make this test, and therefore it would not interfere very much with the regular milling work.

I have contracted for a 12-cell circular battery, to be built on the plan for the Sangerhausen apparatus. All the plans and specifications for the new battery have been purchased by the contractors (the Colwell Iron Works of New York) from the Sangerhausen Company. The battery is to be erected by the Colwell Company, and delivered to the Department there ready for use on or before the first of October. I think it is important to select a place, such as you describe Judge Rost's to be, where all the evaporating and other machinery for working the juices is ready for work.

I propose to make the machinery as simple as possible and to devote all our energies to solving the problem of diffusion.

I expect to go to Louisiana early in March and hope to be able to make some favorable arrangement without delay. The only hope for the success of our experiments is to work with some one who will use every endeavor to make success possible.

The work of the Department will be purely experimental. If it is successful the planter will reap the full benefit of the success; if it is not, no one will suffer any loss.

I do not think I shall ask for more than ten days for the experimental work, and would like to have five days of that time near the first of the season and the other five near the middle of it.

Do you know of any other place where there is a complete apparatus for sugar making which you think would be more favorable than Judge Rost's?

Respectfully,

NORMAN J. COLMAN,
Commissioner.

In March, 1887, the honorable Commissioner of Agriculture visited Louisiana to consult with a committee of the Sugar Planters' Association of that State respecting a suitable plantation on which the work should be done. This committee was composed of the following gentlemen, viz: Hon. D. F. Kenner, John Dymond, Henry McCall, T. S. Wilkinson, L. C. Keever, W. B. Schmidt, J. C. Morris, W. C. Stubbs.

The Commissioner of Agriculture visited, in company with the gentlemen named, the plantations which were thought suitable for the experimental work. After a careful examination the committee made the following report:

Whereas the Government of the United States has determined to test the practical effect of the diffusion process upon the sugar manufacturing interests of the country, and Hon. N. J. Colman, Commissioner of Agriculture, accompanied by Chief Chemist, Dr. H. W. Wiley, having come to Louisiana to arrange for a competitive test with the methods now in use in our State, and Commissioner Colman having requested the aid of the Sugar Planter's Association to select a locality for making the test, the association appointed the undersigned a committee for that purpose. We have therefore inquired into and examined all the places available under the conditions required by the Department of Agriculture.

One of the principal considerations that has guided the committee in making the selection has been to choose that locality which has furnished the most favorable results under the old system, in order that the test should be as severe, as thorough, as complete, and as decisive as possible.

We have examined the various places seemingly available on the Mississippi River, and have carefully inquired concerning those on the Tèche or Attakapas country, and after careful examination and thorough consideration have determined to recommend Governor H. C. Warmoth's Magnolia plantation, in the parish of Plaquemines, as the most suitable locality, from the fact that it would afford the severest competitive test of any place in the State, as the yield on this plantation during several years has been greater per ton of cane ground than on any other place brought under our observation.

March 16, 1887.

JOHN DYMOND, *Chairman.*

D. F. KENNER.

HENRY MCCALL.

T. S. WILKINSON.

L. C. KEEVER.

W. B. SCHMIDT.

J. C. MORRIS.

W. C. STUBBS.

I certify that the above is a true copy of the report of this committee made to the Sugar Planters' Association, April 14, 1887.

JOHN DYMOND,
Chairman.

The superior advantages afforded by Governor Warmoth's sugar-house, the surplus boiler service at his command, and the facilities which he offered for an independent working of the diffusion apparatus were the considerations which led the committee to select his place as the one most suitable to the character of the contemplated work.

At the request of the Commissioner there was appointed by Mr. Kenner, president of the Sugar Growers' Association, an advisory committee to assist those in charge of the work, and thus to help to its successful completion. This committee consisted of Hon. John Dymond, of Belair, and Henry McCall, of Donaldsonville. These gentlemen visited the plantation from time to time during the progress of the work, both of their own accord and by the request of the Commissioner. Following are the reports which they made of the progress of the work :

BELAIR, La., July 15, 1887.

DEAR SIR: In accordance with your request in your favor of 18th instant, I have visited Magnolia plantation, Tuesday, 12th, and Wednesday, 13th instant. The work seemed generally to be well advanced. The house was completed, except the floor. The carbonic-acid pump, filter-press pump, and cutter-engine were all in position and needed only connecting up.

The foundations for the diffusers were being built and will soon be completed. The excavation for cutter was made, but not yet walled up. The lime-kiln was finished, and the washers and connections will be completed this week.

If the diffusion battery comes along promptly, it would seem probable that the whole plant should be ready by October 1, as anticipated.

In consultation with the gentlemen in charge of the work, as you suggested, the matter of a water supply for the diffusers came up. They named 1,200 gallons, I believe, as being the contemplated reservoir of water. It would seem to me desirable to have much more than this, as this limited supply might be exhausted any moment, and it would seem a pity to have the success of diffusion dependent on a water supply which might be cut off in an hour or two from some quite trivial cause. I therefore suggested a 10,000 or 12,000 gallon wooden cistern, which could probably be erected

for \$200, and this would insure the continuance of the experiments during six or eight hours any way, and during that time any accident interfering with the water supply might be overcome.

As one of the most important points to be determined would be the capacity of the battery for twenty-four consecutive hours, it would be unfortunate to have any stoppage for water.

Always glad to act on your suggestions, I am,
Yours, truly,

JOHN DYMOND,
Of Advisory Committee.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

BELAIR, LA., August 2, 1887.

DEAR SIR: I have a letter from Mr. McCall, that he will go with me to Magnolia August 12, and that he can not well go sooner. We shall then report at once to you as fully as practicable.

There is considerable apprehension of danger to the diffusion experiments now felt here, owing to the newspaper report of the choking of the cutters used in Demerara, which cutters are the same used, or contemplated using here.

In response to your request for suggestions, would it not be well to promptly find, by telegram or otherwise, what the exact cause of the trouble is, and whether or not it can be remedied.

This seems to be a serious matter.

Yours, truly,

JOHN DYMOND.

Hon. N. J. COLMAN,
Commissioner of Agriculture.

NEW ORLEANS, August 15, 1887.

DEAR SIR: Your favor of the 3d instant to Mr. Dymond came duly to hand, and on the 12th instant we went to Magnolia and carefully inspected the work done and now going on in the matter of the proposed experiments in diffusion, and we would respectfully report:

That we found the cane-cutter in position, as also the engine for driving it. The shafting and counter-shafting are not yet in place.

The boot of the chip conveyer is in position, but the conveyer is not yet erected, nor is there yet any device to deliver the chips from the cutter to the boot of the conveyer, and we understand Mr. Bartheleny to say that none has been provided.

The diffusers were all in position upon the foundations and columns, but were not connected by any pipe-work, and no platforms or floors were yet constructed about them.

The cars for the discharge of the chips were there, but the circular track for them was not yet down.

The cold-water-supply cistern is not erected.

The carbonating tanks are in position and connected together and ready for connection with the diffusion battery.

The air-compressing pump and the air-receiver, to dry the exhausted chips, were there, and the former in position.

The lime-kiln is completed except the placing of the top casting in position and the erecting of the house and platforms around it.

The washing arrangement for the carbonic-acid gas and the pump to force the gas into the carbonating tanks are all in position and connected.

The pump to take the juice from the carbonating tanks and force the same through the filter presses is in position, as are also the filter presses, except one, that we were

told was to come from Fort Scott. The connections with the presses were not completed.

The sulphuring tanks, and also the sulphur stoves and sulphur air pump, were in position, and the filter presses for the sulphured juice were also in position.

To write of the matter more generally, we should say that while there seems yet much to do in the way of details, yet we think excellent progress has been made, and that unless some unforeseen delay occurs the apparatus will be ready in due time for the experiments.

The cane-cutter is a beautiful machine, but its complete failure in Demerara, where its duplicate was used, and whence we now have the report of Mr. Quintin Hogg, the proprietor, that it took forty-eight hours to slice 108 tons of cane, indicates its complete uselessness for the purpose, as it is now constructed.

This excites considerable anxiety here, as with all of our machinery now in position we are absolutely without any cutter that can cut the canes.

Other cutters may demand different arrangements of gearing and shafting that might result in delay if not at once considered and provided for.

Mr. Barthelemy thinks that the difficulty with the present cutter arises from the fact that the short-ends of the canes can not be held in position for the cutters to act on them, and that a system of spring rollers might be added to hold these ends in position until the slicing is completed.

This seems plausible, and it might be well for you to give him authority to experiment in that direction, but it seems to be almost too late to experiment now, and especially so when we know that the failure of the same machine has terminated the experiments in Demerara, making it a disaster. Mr. Hogg reports they return to the cane-mill process there until proper cutters are provided. He does not seem disposed to experiment with the cutters.

It would seem extremely desirable to provide the cutters that succeeded in Java, as you suggest, and further to provide those you now have at Fort Scott, as you suggest, as the whole experiment may be placed in peril from these difficulties in cutting. We shall be pleased to be of any further service we can, and remain,

Yours, respectfully,

JOHN DYMOND,
HENRY MCCALL,
Advisory Committee.

Dr. H. W. WILEY,
Chemist, Department of Agriculture, Washington, D. C.

CANE-SLICER.

In order to secure a multiple feed for a single cutter it was determined to adopt the horizontal disk system. Cutters of this kind not being made in this country, it was necessary to purchase one in Europe.

The cutter built by the Sangerhauser Company, of Sangerhausen, Germany, was selected. This cutter was guaranteed to give from 200 to 250 tons of chips per twenty-four hours, suitable for diffusion.

This slicing-machine, having been tried in Demerara in the early summer, proved inefficient. To guard against failure from lack of a proper cutter, another machine which had already proved successful in Java was ordered from the Sudenburg Company of Magdeburg.

The small cutter, with a horizontal disk, tried at Fort Scott last year, was also sent to New York for certain alterations, and thence to Magnolia. Unfortunately the new knives sent with the machine had not

been properly tempered, and this prevented the use of this cutter for the preliminary experiments.

Mr. R. Sieg, of New Orleans, who had had large experience in working cane-cutters in Louisiana in 1874 and the following years, was also instructed to build a cutter with vertical disk and multiple feed. We found, however, that the time at his disposal was too short to permit the building of such a machine as he desired.

On October 6, I received the following instructions :

You are hereby instructed to go to Fort Scott, Kans., and after inspecting the work of the Department there in the manufacture of sugar, you will proceed to Lawrence, La., to conduct the work of the Department at that place in the application of diffusion to the extraction of sugar from sugar-cane.

You are also authorized to travel between Magnolia Station and New Orleans as often as may be necessary to secure the proper conduct of public business.

Very respectfully,

NORMAN J. COLMAN,
Commissioner.

In obedience to the above instructions I reached Magnolia on the evening of October 17, 1887. The experimental work was conducted without being complicated by the use of any process or machinery in which any one in the employment of the Department had any patented or financial interest whatever. The sole object in view was to benefit those engaged in the manufacture of sugar in all parts of the country. Experiments conducted at public expense should, in my opinion, be for the public good, and not for the benefit of a private individual or corporation.

On the morning of the 19th the diffusion building was badly injured by a cyclone. The water tank to supply the battery, together with the tower supporting it, was blown on to Governor Warmoth's sugar-house, causing great damage. Nearly a month was required to repair the damage and restore the building and apparatus to the condition in which it was before the storm.

The delays incident to the working of new machinery were numerous. The original plan contemplated having all the machinery ready by the 1st of October, thus permitting a series of preliminary trials extending over a month before the regular season began.

Instead of this, however, unavoidable delays, incident to the imperfections of the machinery and the damage of the storm, postponed even the preliminary experiments until the beginning of December.

A recital of the details of these delays would only lengthen the report without adding anything to its value. It must be said, however, in this connection that the gentlemen associated with me worked earnestly and faithfully through all the discouragements attending the preparation of the machinery.

Mr. Ernest Schulze, representing the Sangerhauser Company, was also present, and rendered valuable assistance in putting his canceller in working order,

The numerous defects in the battery and the cutter having been remedied, the apparatus of the Colwell Company was accepted on December 11, 1887.

Mr. A. W. Colwell, the president of the company, was present during the final trials of the battery, and rendered valuable assistance in putting it into working order. The defects in both cutter and battery were of a minor character, but were such as to greatly delay the use of new machinery for new purposes. The final working of all the machinery was excellent and satisfactory. The season's experiments, however, disclosed many improvements of a seemingly trivial nature, but by the adoption of which a more economical working of the diffusion process can be secured. These improvements will be discussed in another place.

The first results from the experiments were obtained from the run of December 3, 1887.

The juice was treated with .3 per cent. its weight of lime, and after the precipitation of the lime with carbonic dioxide, an amount of lignite equal to 10 per cent. of the weight of the sugar present was added.

The juice filtered readily through the presses, forming firm, hard cakes. The filtered juice was treated with phosphate of soda, 15 pounds of this salt being added for each 5,000 pounds of juice.

The phosphate produced an abundant flocculent precipitate, which filtered easily through the twin filter presses, giving a juice of remarkable limpidity. The *masse-cuite*, however, was dark, and the molasses much inferior in color to that made by the use of bone-black and ordinary clarification.

The phosphate of soda did not produce as favorable results as had been expected, and its further use was discontinued.

Following are the data obtained in the first run :

First diffusion run, December 3, 1887.

	Total solids.	Sucrose.	Glucose.
Juice from chips :		<i>Per cent.</i>	<i>Per cent.</i>
First	15.20	12.01	.96
Second.....	14.45	11.92	1.00
Third.....	15.45	12.84	1.02
Average.....	15.03	12.26	.99
Diffusion juice :			
First	10.88	8.88	.83
Second.....	10.40	8.65	.74
Average.....	10.61	8.76	.78
Exhausted chips :			
First sample.....		.51	.....
Second sample.....		.76	.....
Third sample.....		.91	.....
Average.....		.73	.....
Carbonated juice	11.09	9.20	.70
Waste water.....			.12
Semi-sirup.....	51.80	42.20	3.39
First sugar.....		97.50	
Molasses from first sugar.....	76.30	45.00	11.11
Second sugar.....		91.60	

Cane used.....	tons..	80.3
First sugar per ton.....	pounds..	146.1
Second sugar per ton.....	do.....	40.1
Total first and second sugars.....		186.2
Third sugar.....		15.0
		Pounds.
The total sugar in the cane at 90 per cent. juice was.....		220.6
Of this there was obtained 146.1 pounds at 97.50.....		144.4
And 40.1 pounds at 91.6.....		36.7
Total pure sucrose obtained.....		181.1
Left in chips.....		14.6
Total left in molasses and lost in manufacturing.....		24.9

(NOTE.—The third sugar will not be dried until in May or June, 1888. The estimates of third sugar have been made by Mr. E. C. Barthelémy.)

EXTRACTION.

The percentage of sucrose left in the spent chips was .73. Sucrose in cane was 11.03 per cent. The per cent. of extraction is therefore $11.03 - .73 = 10.30 \div 11.03 \times 100 = 93.4$.

SECOND TRIAL.

Another trial was made of the diffusion machinery beginning December 9. Carbonatation was again used, but without lignite or any further treatment. The juice passed directly from the filter presses to the double-effect pan.

The quantity of lime employed was .6 per cent. the weight of the juice. The filtration was perfect. The experiment was remarkable in showing that a perfect defecation can be made with carbonatation with a much smaller percentage of lime than had been supposed necessary.

The *masse cuite* was dark, but the sugar a fair yellow.

Following are the data of the run :

Second diffusion run, December 9, 1887.

	Total solids.	Sucrose.	Glucose.
		Per cent.	Per cent.
Fresh chips:			
First sample.....	14.06	11.70	1.04
Second sample.....	15.65	13.64	.76
Third sample.....	15.70	13.52	.75
Fourth sample.....	15.50	13.02	.81
Fifth sample.....	14.00	11.18	1.02
Average.....	14.98	12.61	.88
Diffusion juice:			
First sample.....	9.36	7.83	.67
Second sample.....	8.67	7.25	.58
Third sample.....	9.68	7.61	.55
Fourth sample.....	10.40	8.69	.91
Fifth sample.....	10.20	8.45	.78
Average.....	9.66	7.96	.69
Carbonatated juice:			
First sample.....	9.12	7.73	.65
Second sample.....	8.74	7.35	.57
Third sample.....	10.20	8.55	.50
Fourth sample.....	11.40	9.00	.73
Average.....	9.86	8.16	.61

Second diffusion run, December 9, 1887—Continued.

	Total solids.	Sucrose.	Glucose.
		Per cent.	Per cent.
Exhausted chips:			
First sample.....		1.58	.....
Second sample.....		1.69	.....
Third sample.....		.48	.....
Fourth sample.....		.32	.....
Fifth sample.....		.40	.....
Average		.89	.....
Semi-sirup	47.70	88.90	2.96
First sugar.....		96.60	.....
Molasses from firsts.....	72.20	42.40	10.50
Second sugar.....		87.30	.....

	Pounds
Yield of first sugar per ton	128
Yield of second sugar per ton.....	43
Cane used, tons	90
The total sugar in the cane at 90 per cent. juice was.....	per ton.. 238.98
Of these there was obtained 128 pounds at 96.6	123.6
And 43 pounds at 87.3	37.5
Total pure sucrose obtained	per ton.. 161.1
Pure sucrose left in chips	do 17.8
Pure sucrose left in molasses and lost in manufacture.....	do 41.1
Third sugar estimated.....	do 17.0
Percentage sugar in cane extracted	92.16

The poor yield was due to use of thick chips during the first part of the run, causing a loss of 1.6 per cent. sucrose in the chips.

* Following are the analytical data of the run :

THIRD TRIAL.

In this run the use of carbonatation and lignite was discontinued. The diffusion juices were treated with sulphur fumes until well saturated. They were then treated with lime and clarified in the usual way.

The clarification took place readily. The quantity of scums was very small, and the sediment subsided rapidly, forming a thin layer on the bottom of the tank, permitting the clear liquor to be easily and completely drawn off. The juice passed at once from the clarifiers to the double effect pan and subsequently received no further purification.

Following are the analytical data obtained:

Third diffusion run December 10 and 11, 1888.

	Total solids.	Sucrose.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>
Fresh chips:			
First sample	14.39	11.89	.79
Second sample	12.77	10.63	.77
Third sample	14.49	12.06	.80
Average	13.88	11.53	.78
Diffusion juice:			
First sample	9.42	7.82	.62
Second sample	9.41	7.87	.59
Third sample	9.55	7.86	.67
Average	9.46	7.85	.63
Sulphured juice:			
First sample	9.09	8.17	.66
Second sample	9.12	7.53	.58
Average	9.40	7.85	.63
Clarified juice:			
First sample	9.95	8.21	.67
Second sample	9.89	8.06	.63
Third sample	10.32	8.39	.71
Average	10.05	8.22	.67
Exhausted chips:			
First sample		.80	
Second sample		.50	
Third sample		.77	
Fourth sample		.93	
Average		.75	
Semi-sirup	44.70	34.60	2.87
First sugar		96.30	
Molasses from first sugar	72.90	36.70	12.07
First sugar, per ton		pounds..	143
Number tons cane used			110

The molasses from the first sugar was boiled to string proof, and put in wagons. A good crystallization of second sugar was secured but, the molasses having been left too acid, a good separation was not secured. Mr. Barthelémy therefore decided to reboil the molasses with some of the product of the mill process, and therefore no statement of the quantity of second sugar can be given. It was estimated at 30 pounds per ton.

The cane from which this run was made was grown on new back land and was the poorest of the whole season.

The percentage of sugar extracted of total sugar in cane was 92.80.

FOURTH TRIAL.

In this run the diffusion juice was treated with lime until almost neutral. It was then boiled, skimmed, and allowed to settle. The scums and sediments were of small volume and were all returned to the battery.

The juice received no other treatment whatever for clarification. It was converted to sirup in a double effect vacuum pan. The capacity of this pan was not quite great enough to evaporate the juice as fast as furnished by the battery. For this reason the run which might have

been finished in two days occupied a part of a third day. The quantity of cane worked was 200 tons.

Following is a record of the analytical data obtained :

Fourth diffusion run December 29, 30, and 31, 1887.

	Total solids.	Sucrose.	Glucose.
Juices from fresh chips:		<i>Per cent.</i>	<i>Per cent.</i>
A. M., first day	16.46	14.23	.49
P. M., first day	17.27	15.33	.43
Midnight, first day	17.26	15.12	.43
A. M., second day	17.13	14.84	.45
Midnight, second day	16.97	14.93	.54
A. M., third day	16.19	13.90	.61
P. M., third day	16.26	14.05	.50
Average fresh chip juice for run	16.79	14.60	.49
Diffusion juices:			
First sample, first day	9.72	8.71	.32
Second sample, first day	10.09	9.01	.29
Third sample, first day	11.38	10.16	.30
Fourth sample, first day	11.60	9.31	.53
First sample, second day	11.10	9.87	.32
Second sample, second day	10.92	9.09	.33
Third sample, second day	10.94	9.77	.44
First sample, third day	10.45	9.31	.35
Second sample, third day	10.87	9.69	.38
Average diffusion juice for run	10.78	9.50	.36
Clarified juices:			
Average for first day	10.75	9.34	.32
Average for second day	11.77	10.36	.32
First sample, third day	12.01	10.36	.41
Second sample, third day	11.61	9.78	.38
Third sample, third day	11.25	9.51	.36
Average clarified juice for run	11.48	9.87	.36
Juices from exhausted chips:			
First sample, first day		.52	
Second sample, first day		.61	
Third sample, first day		.83	
First sample, second day		1.12	
Second sample, second day		.72	
Third sample, second day		.95	
First sample, third day		1.09	
Second sample, third day		1.30	
Third sample, third day		1.10	
Average exhausted chip juice for run		.91	
Semi-sirup for first strike	87.37	83.10	.99
Masse-cuite first strike		81.20	
First sugar from first strike		98.40	
First molasses from first strike	78.22	51.80	7.76
Semi-sirup for second strike	40.00	35.10	1.19
Masse-cuite		80.60	
First sugar		98.90	
Molasses from second strike	79.00	55.60	
Average extraction		93.8	
Pounds first sugar per ton		163.5	
Per cent. sugar extracted obtained in firsts		66.2	
Second sugar per ton		pounds..	45.9
Third sugar per ton (estimated)		do ..	*18.0
Cane used		tons..	200

FIFTH TRIAL.

The fifth and last run of the diffusion battery was begun on January 14 and finished on the 18th. This trial was made after the milling work had been completed. The diffusion juices were treated precisely

* On February 29 I was informed by letter from Governor Warrmoth that the third sugars from the fourth run had been dried and weighed, yielding 3,723 pounds or 18.6 pounds per ton.

the same way as the mill juices had been, and after passing over bone-black were concentrated to sirup in a Yaryan quadruple effect, which had been in use with the mill juices during the manufacturing season.

The working of all the machinery during this final trial was admirable, and the even march of the whole work promoted the efficiency of the machinery and the successful manipulation of the juice.

Analytical data of fifth run.

No.	Brix.	Sucrose.	Glucose.	No.	Brix.	Sucrose.	Glucose.
Fresh chips:		<i>Per cent.</i>	<i>Per cent.</i>	Diffusion juices—con-		<i>Per cent.</i>	<i>Per cent.</i>
397.....	16.87	14.23	.74	tinued.			
400.....	16.39	13.45	.87	450.....	9.88	8.12	.42
403.....	16.79	13.79	.89	453.....	10.87	9.00	.38
405.....	17.09	14.73	.68	460.....	9.89	.....	.45
408.....	16.86	12.11	.75	465.....	10.67	8.41	.61
411.....	17.16	14.73	.64	469.....	10.47	8.01	.73
414.....	16.93	14.06	.70	473.....	10.17	8.02	.48
417.....	17.00	14.50	.61	476.....	10.15	7.86	.48
420.....	16.70	13.93	.73	479.....	10.31	7.92	.47
423.....	16.79	14.11	.74	485.....	10.59	8.26	.59
426.....	17.19	14.17	.61	491.....	9.69	7.53	.61
429.....	16.73	14.19	.56				
437.....	17.11	14.55	.61	Maximum.....		9.28	.73
440.....	16.17	13.48	.75	Minimum.....		7.53	.31
443.....	16.17	13.43	.76	Mean.....		8.41	.47
446.....	16.60	13.99	.63				
449.....	16.63	14.39	.65	Exhausted chips:			
452.....	16.77	14.28	.63	399.....		.52	.....
459.....	16.23	13.29	.77	402.....		.21	.....
465.....	16.03	13.79	.76	407.....		.52	.....
468.....	16.07	13.35	.85	410.....		.32	.....
472.....	16.84	14.34	.64	413.....		.52	.....
475.....	16.37	13.54	.82	416.....		.41	.....
478.....	16.51	14.17	.70	419.....		.33	.....
481.....	16.94	14.88	.65	422.....		.42	.....
490.....	16.57	14.52	.63	425.....		.42	.....
				428.....		.55	.....
Maximum.....		14.73	.89	431.....		.42	.....
Minimum.....		12.11	.59	439.....		.50	.....
Mean.....		13.98	.70	442.....		.50	.....
				445.....		.42	.....
Diffusion juices:				448.....		.46	.....
396.....	11.37	9.28	.60	451.....		.69	.....
401.....	10.67	8.66	.61	454.....		.85	.....
404.....	10.61	8.92	.49	461.....		.51	.....
409.....	10.38	8.53	.41	467.....		.42	.....
412.....	11.01	9.10	.45	470.....		.39	.....
415.....	10.91	8.60	.48	474.....		.43	.....
418.....	10.71	8.76	.40	477.....		.54	.....
421.....	10.65	8.77	.40	480.....		.34	.....
424.....	10.57	8.51	.44	486.....		.22	.....
427.....	10.52	8.90	.46	492.....		.48	.....
430.....	10.65	9.05	.32				
438.....	10.27	8.46	.35	Maximum.....		.69	.....
441.....	10.73	8.91	.45	Minimum.....		.21	.....
444.....	10.88	8.99	.42	Mean.....		.44	.....
447.....	49.5	7.68	.34				

The molasses from the first sugars being very rich, the method of re-boiling to grain was employed. To this end the molasses of the first strike, having been reduced to 55 to 60 per cent. of total solids, was boiled on a nucleus of first sugar left in the pan from the second strike. In this way all the molasses was boiled to grain with most gratifying results except that from the last strike of the first sugars.

The attempt to boil this to grain did not succeed in giving a *masse cuite* which could be dried with ease. The molasses running from the machines was so thick that it clogged them up. Seven large sugar wagons were filled with this material and set in the hot room.

The sugars made were equal in every respect to those obtained by milling in similar instances. Without counting the second sugar above named, the grained sugar per ton amounted to 181.5 pounds. The grained sugars in wagons will yield not less than 7,500 pounds or 18 pounds per ton.*

The third sugars are estimated by Mr. Barthelemy at not less than 16 pounds per ton.

The total yield per ton of the fifth run will reach therefore 215.5. The number of tons of cane used was 417.

Summary of results.

Number of run.	Cane.	Mean sucrose in juice.	Mean glucose in juice.	Sugar grained in pan per ton. First sugar.
	<i>Tons.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Pounds.</i>
1.....	80.3	12.20	.99	140.1
2.....	90.0	12.61	.88	128.0
3.....	110.0	11.53	.78	143.0
4.....	20.0	14.60	.49	165.5
5.....	417.0	13.98	.70	181.6

Wagon sugar per ton.		Total sugars per ton.
Second sugar.	Third sugar (estimated).	
<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
40.1	15	201.2
43.0	18	189.0
*30.0	12	185.0
45.9	18	229.4
*18.0	16	†215.5

* Estimated.

† Actual weight, 16.3 pounds per ton, and 213.8 pounds total sugars per ton. The third sugars from this run were mixed with molasses from the mill products, and no separate return of it will be made.

COMPARATIVE YIELDS BY MILLING AND DIFFUSION.

The yield in first or grained sugars affords the best comparison of the two systems of manufacture. Judged by this standard the diffusion process had given a yield of sugar fully 30 pounds per ton greater than was afforded by milling. For further data on this point see the report of Governor Warmoth farther on.

CHARACTERISTICS OF DIFFUSION JUICE.

The juice of diffusion differs from the mill juice chiefly in its content of water. In addition to this, also, must be noted a slight increase in the ratio of glucose to sucrose. This is due doubtless to a slight inversion of the sucrose during the process of diffusion. From a commercial

* The actual yield reported to me February 23, by Governor Warmoth, was 6,800 pounds, or 16.3 pounds per ton.

point of view the loss is insignificant. Further, it may be said that there appeared to be in the diffusion juice treated in the ordinary way a slightly increased amount of gummy matter. This was noticed only in filtering the sirup through bone-black. In the strike-pan and the centrifugal the products of diffusion worked fully as well as those from the mill.

DISPOSITION OF CHIPS.

An attempt was made to pass the chips through the five-roll mill, but it was found impracticable. The first rolls would not take them easily, and the second set of rolls had to be opened somewhat to secure the proper feed. The bagasse issuing from the mill contained still 65 per cent. water and made a poor fuel.

It would probably not be a difficult problem to so adjust the mill as to secure a proper drying of the chips. To return the chips to the soil, however, appears to be the most rational method of disposing of them.

It is true that if spread too thickly on the soil the chips may prove highly injurious, but if distributed in a thin layer, covering almost if not quite the original acreage of the cane furnishing them, they would certainly prove advantageous. The chips would not only furnish organic matter to the soil and thus increase its porosity, but they also contain still a considerable part of nitrogenous matter, which would afford a valuable plant food. Even the richest land should be treated fairly, and the cane-field should receive as nearly as possible as much as it gives. The additional cost of replacing the chips on the field is a matter which should receive attention here, but the benefit will apparently be greater than the expense. During the manufacturing season the chips can be deposited in large beds, which subsequently can be transferred to the field. If time for the partial decay of the chips should be desired, the accumulation of one season need not be moved until the following year.

DISPOSITION OF SCUMS AND SEDIMENTS.

The scums and sediments were successfully treated by the process of carbonatation. The expense of a lime-kiln is not necessary for this work. It was satisfactorily done by drawing the carbonic dioxide gas directly from the stack of the boilers. As high as 11 per cent of CO_2 was found in the gases from this source.

The scums, etc., treated with 2 to 3 per cent. of lime, are subjected to the action of the gas until the lime is precipitated. They then can be easily and rapidly filtered.

By means of a cheap and convenient *monte jus* the scums and sediments were also returned to the battery. The method of operating was as follows :

The scums and sediments from the clarifiers were collected in a tank furnished with a steam coil to keep them at the boiling temperature.

This tank was connected with a *monte jus* of 50 liters capacity. This apparatus was connected with the compressed-air service used in operating the battery. It was so arranged that the master of diffusion, or his assistant, could operate it directly from the central column of the battery.

After each cell was filled with chips, 50 liters of the scums were run into the *monte jus* from the storage tank, and, by means of compressed air, poured into the full cell. The process of diffusion was then continued in the usual way. The quantity of liquid drawn from each cell was increased by the amount of scums added. For instance, if 900 liters were the amount regularly drawn, 950 would be taken from a cell to which the scums had been added, as above indicated.

No deterioration of the diffusion juice could be detected in using this method.

This procedure was also used during the progress of the work conducted by the Department at Fort Scott during the season of 1887. I have been told that a patent has been applied for to cover this process, and have therefore placed on record the experiments made at Lawrence for the public benefit.

THE USE OF LIGNITE.

In order to get lignite of the best possible variety and in the best form for use, a few tons of the ground article were purchased from the inventor of the process of filtering with brown coal, Mr. Fritz Kleeman, of Schönigen, Germany.

I have already alluded to the successful use of lignite in conjunction with lime and carbonic acid.

This experiment, however, did not show that any beneficial effects were produced by the introduction of the lignite.

Afterwards experiments were made by Mr. Kleeman himself, using lignite alone. Mr. Kleeman said the arrangement of the clarifying tanks was not suitable to the process. The filter cloths were soon clogged and the attempt at filtration had to be abandoned.

Later in the season I received a letter from Mr. W. J. Thompson, of Calumet Plantation, in which he said that he would make a trial of the process under more favorable conditions than obtained at Magnolia, and requesting me to send him enough of the Kleeman lignite for that purpose. This I gladly did. Mr. Thompson made a run of nineteen clarifiers with lignite, but found so many difficulties attending the work that its further progress was abandoned.* On the other hand, Professor Stubbs, at Kenner, working with a small press, secured results that were highly satisfactory.

The results of the work with lignite show—

(1) That on a large scale the filtration takes place with great difficulty, unless a very great quantity of the lignite be used and the juice be neutral or slightly alkaline.

* See Appendix B, p. —.

(2) That with a slight excess of lime, precipitated with carbonic acid, lignite can be successfully used to increase the filtering surface.

(3) The decolorizing power of lignite varies with the nature of the sample. In some cases this property is present in a high degree; in others, entirely absent.

(4) The successful working of the process on a small scale would indicate that it might be worked commercially.

(5) In juices as pure as those of sugar-canes, filtration through lignite, even if easily done, does not seem to be necessary.

I had expected to have Mr. Thompson's complete report on the experiments with lignite before this time, but it has not yet been received.

COMPARATIVE YIELD FROM MILL AND DIFFUSION BATTERY.

The comparative yield from the cane-mill and the diffusion battery is given by Governor Warmoth in a paper read before the Planter's Association at the February meeting, viz :

The first cane worked was from second-year stubble, and it gave us 146 pounds of first sugar to the ton and 40 pounds of seconds.

The molasses was put into the cisterns with the other, and we can not give any estimate of the thirds. Our mill gave us 145 pounds first and second sugars from this cane.

The next test was from some green cane, grown on new land, yielding 28 tons of cane per acre—considerably blown down and sprouted in a small degree. This had much less sugar in it than the first cane. Yet we got 128 pounds of first sugar and 43 pounds second sugar per ton from it.

Our mill gave us 140 pounds of first and second sugar per ton from this cane.

The next run gave us 165.5 pounds firsts, 45.9 of seconds; total, 211.4 pounds, with thirds in the wagons, which we estimate will give us 15 pounds more, a total of 226.4 pounds.

The next run was on 450 tons of cane, beginning on the 13th of January, ending on the 18th. This cane was rich and fine. It had been killed on the 26th of December, was not windrowed, but was in fine condition. From this cane diffusion gave us 181 pounds of first sugar and grained seconds, with enough left in the wagons to bring it up to 223 pounds. From this cane we got 193 pounds of first and second sugar by our mill.*

All of this shows about the same difference between diffusion and our mill-work of about 35 pounds of sugar per ton of cane. I do not mean to be invidious when I say that I think we got a little better extraction by our mill than any of our neighbors. My friend, Mr. Dan Thompson, got more sugar to the ton of cane in 1886 than we did, but this result was obtained not so much by his extraction as by the skillful work in the balance of his house, in which I firmly believe the equal does not exist in Louisiana.

It is safe to say that the average yield per ton of cane in the State is not over 110 pounds. I believe diffusion will bring the average up to within the neighborhood of 200 pounds—a gain of certainly 75 pounds, and perhaps 90 pounds, per ton of cane.

* Mr. Thompson's report was received March 5. See Appendix B.

NOTE.—In respect of the last run, the analytical data show that the cane worked by the mill during its last run, from which 193 pounds per ton were made, was richer in sucrose by nearly 1 per cent. than that worked at the last diffusion run.

My nearest neighbor, Mr. Bradish Johnson, obtained the past season 136 pounds of sugar per ton of cane. We are within 3 miles of each other; our land is much the same; our cultivation is substantially the same. It is fair to assume his cane was as rich as mine, yet we had about 175 pounds of all sugar per ton, a difference of 39 pounds of sugar per ton on our mill-work, and about 71 pounds difference on the diffusion work. Take his estate for illustration:

His 10,000 tons of cane gave him 1,390,000 pounds of sugar. Had he worked his crop by diffusion he would certainly have had 70 pounds more sugar to the ton of cane. This would have increased his yield 700,000 pounds of sugar, which, at 5½ cents per pound, would have given him \$38,500 more for his crop than he received.

Take my own crop of 13,300 tons of cane. Had I worked it by diffusion I would have had 35 pounds more sugar per ton. This would have given me 465,000 pounds more sugar than I obtained, an aggregate of 2,865,000 pounds of sugar from about 600 acres, or 4,750 pounds per acre. The cash increase of my crop would have been, at 5½ cents per pound, \$25,592.50, a difference to Mr. Johnson of \$3.85 per ton of cane, and to me, on my crop, of \$1.82½ per ton of cane.

QUANTITY OF JUICE DRAWN FROM EACH CELL.

The cane used for diffusion was weighed and delivered, chiefly on cars, to the cutter. The trash which becomes detached in handling the cane was collected in carts and weighed, and its weight deducted from the total. No account was taken of the trash which entered the cutter.

It was found that the average weight of chips in each cell, when filled in the ordinary manner, was 1,757 pounds. One cell filled with extra care was weighed, and the weight found to be 1,860 pounds. It was thus seen that by careful packing it was easy to get 100 pounds extra weight of chips into each cell.

The quantity of juice drawn from each cell varied from 900 to 1,000 liters, or from 2,059 to 2,288 pounds.

The mean quantity of juice drawn for the first four runs was nearly 2,170 pounds. Assuming that in each 100 pounds of chips there is 90 per cent. of juice, we have in 1,757 pounds of chips 1,581.3 pounds of normal juice.

The quantity of diffusion juice from this was 2,170 pounds. The increase over normal juice is therefore 589 pounds, or 37.2 per cent. In the last run a much greater dilution was secured. In order to get a slow current of the juice through the calorimeters the master of diffusion was instructed to begin filling the cell with juice when it was about half full of chips. At the end of the run it was found that the introduction of liquid had caused a floating of the chips, and that the weight of chips in each cell has been greatly diminished. Thus a higher dilution of the diffusion juice was secured than was intended. The very perfect exhaustion of the chips during the last run was partially secured by this means.

The mean weight of chips in each cell during the last run was 1,500 pounds; the weight of normal juice 1,350 pounds, giving an increase of 60 per cent. This dilution is greater than is necessary for diffusion

work. With a battery of sixteen cells I think the dilution could be easily reduced to 30 per cent. and the extraction be satisfactory.

COAL CONSUMED.

The quantity of coal consumed depends first on the efficiency of the boilers and evaporators employed, second on the quality of the coal, and third on the dilution of the juice.

In beet-sugar factories the basis of computation is generally based on the dilution arising from drawing 180 pounds of diffusion juice from each 100 pounds of beet cuttings. In respect of evaporation what is found to be true of beet juices will also apply to cane juices of the same density.

From the arrangement of the machinery at Magnolia it was found impossible to measure the quantity of coal consumed by the diffusion work. In the last run, when the milling work was over, the centrifugals were run drying seconds and the vacuum pan boiling thirds during the process of the work.

In addition to this, a part of the steam used was furnished by the bagasse boilers, using wood and coal as a fuel—not an economical method of making steam.

As nearly as could be estimated, the quantity of coal required to make a pound of sugar was 2 pounds. The actual quantity of coal which would be required with the best boilers and evaporators may be found by consulting Dr. Karl Stammer's latest edition of "Text-book of Sugar Making," pages 873 *et seq.*

When 180 pounds juice are taken for each 100 pounds beets the consumption of coal to reduce the juice to a sirup of 60 per cent. total solids is as follows:

	Pounds.
With double-effect pan	13.5
With triple-effect pan	9.10
With quadruple-effect pan	6.76

To reduce the sirup to *masse cuite* requires 4.44 pounds.

We find, therefore, the following quantities of coal necessary for each 100 pounds raw material giving 180 pounds of juice:

	Pounds.
For a double effect	17.94
For a triple effect	13.54
For a quadruple effect	11.20

If now we take the ordinary dilution for sugar-cane, the following numbers are found:

In evaporating 180 pounds of diffusion juice from 100 pounds cuttings to 60 per cent. sirup 156 pounds of water are evaporated. In evaporating 125 pounds of diffusion juice to same density, only 101 pounds of water are driven off. To evaporate 156 pounds of water 13.26, 9.10, and 6.76 pounds of coal are used for double, triple, and quadruple effects, respectively. For the same weight of cane chips, giving 125 pounds of

diffusion juice, the quantities of coal consumed would be 8.58, 5.89, and 4.44 pounds, respectively. To reduce this to *masse cuite* would require the same consumption as before, viz, 4.44 pounds. One hundred pounds of cane chips will yield by diffusion an average of 10 pounds of sugar for the whole State of Louisiana. The coal consumed in evaporation, therefore, would be:

	Pounds.
For a double effect	13.02
For a triple effect	10.33
For a quadruple effect.....	8.88

The above computation includes the exhaust steam from the pumps, centrifugal engine, etc. The quantity of steam required to run the battery must be added to the above. It certainly would not amount to more than two pounds per hundred of cane used.

With the best apparatus most economically arranged the total consumption of coal per 100 pounds of cane would be:

	Pounds.
For a double effect	15.02
For a triple effect	12.33
For a quadruple effect.....	10.88

Reduced to 1,000 pounds of sugar from cane yielding an average of 10 per cent. of all sugars, the figures become:

For 1,000 pounds sugar—	Pounds.
With double effect	1,502
With triple effect	1,233
With quadruple effect.....	1,088

In all these calculations the coal is assumed to be of fair average quality, and to be able to convert 6 pounds of water into steam at usual boiler pressure for each 1 pound of coal. In general, then, it may be said the quantity of coal required to make 1,000 pounds of sugar by diffusion varies from 1,000 to 1,500 pounds, according to the system of evaporation employed.

Diffusion can only be made an economical success when the best machinery and the most economical methods are employed. The great objection which has been urged against it, viz, the increased consumption of fuel required, is entirely removed when the process is carried on under the economical conditions which have been mentioned.

To attempt to introduce diffusion with old and worn-out apparatus, defective boilers and open pans, would simply be disastrous. It can only succeed when the highest mechanical skill, associated with the best scientific control, directs all the operations of the sugar house.

In the one experiment where actual weighings have been completed of the whole product, viz, the fourth run, the quantity of sugar made per ton is:

	Pounds.
First	165.5
Seconds.....	45.9
Thirde.....	18.6

Total 230.0

I do not think, therefore, that it is extravagant to believe that with the best culture and most economical method of manufacture the yield per ton of cane in Louisiana may be brought up to 200 pounds. The introduction of diffusion means almost a complete rehabilitation of the average sugar house. It would be unreasonable to expect that planters will have the money and the desire to undertake such a radical change, or at least to make it rapidly.

But it seems to me that the gradual introduction of diffusion, with its concomitant machinery, will work a great change in the sugar industry of the South, bringing success and prosperity where, for years, a hard struggle for existence has been going on.

The final result, I sincerely hope, will bring into cultivation the extensive areas of rich sugar lands now lying idle and increase the production of the State of Louisiana to 500,000 tons annually.

I can not close this report without expressing my hearty appreciation of the support I have received from the sugar planters. The great majority of them were skeptical in respect of the process, but all were anxious that a thorough trial should be made.

Particularly I desire to thank Governor Warmoth for his constant and enthusiastic support and for generously giving \$5,000 and more to continue experiments, when the funds appropriated for them had been exhausted by the expensive delays caused by the cyclone and imperfections in the machinery. Without this timely aid the whole work would have been stopped on the very threshold of success.

The advice and encouragement of Messrs. Dymond and McCall, members of the advisory committee, helped me greatly during the most trying days of the work, when it seemed an almost hopeless task to wrestle further with difficulties of a purely mechanical nature.

The active co-operation of Mr. J. B. Wilkinson, jr., was a source of constant assistance during the whole progress of the work, which is but inadequately recognized by a simple sentence of thanks.

Of my own assistants, Messrs. Barthelemy and Spencer had charge of the erection of the building and of the apparatus, except that put up by the Colwell Company.

Mr. Barthelemy took charge of the sugar making during the various trials and Mr. Spencer had the general supervision of the diffusion process and particularly of the limekiln and carbonatation apparatus. Messrs. Crampton and Fake took charge of the chemical work. Mr. John Dugan was master of diffusion. Mr. R. Sieg, as consulting engineer, rendered much assistance. His long experience and thorough knowledge of the literature of diffusion rendered his services particularly valuable.

Finally, I will say that no one recognizes more fully than myself the many imperfections noticed during the progress of the experiments in the machinery and methods employed. I have endeavored not to conceal these, believing that in pointing them out a service is rendered the public only less valuable than that secured by complete success,

APPENDIX A.

Letter of the Commissioner in transmitting report of M. Swenson to the Senate.

UNITED STATES DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., February 2, 1888.

SIR: In response to a resolution of the Senate of the 30th ultimo, I have the honor to transmit herewith a copy of the report made to this Department by Professor Swenson on the subject of sorghum sugar.

For the further information of the Senate I beg to say that experiments in the manufacture of sugar have been conducted by this Department during the past season at three stations, namely, Rio Grande, N. J.; Fort Scott, Kans.; and Magnolia Plantation, La. The two first-named stations worked with the sorghum cane and the last-named station with sugar-cane. I was led to change my original intention to publish the reports of these stations separately by the belief that the combination of the three reports in one volume would make a more useful, practicable, and valuable document for purposes of comparison and otherwise—a document which would be especially valuable in the South to sugar-planters, who might thereby be led to greatly prolong their sugar-working season by planting both the sorghum and the sugar cane.

The material portions of the reports of the two first-named stations were thereupon made public through the press and their official publication delayed, awaiting the termination, last week, of the experiments at Magnolia. The manuscript for this report is now ready for the printer, and it will be published as an official report of this Department within a few days.

Very respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

HON. JOHN J. INGALLS,
President pro tempore, United States Senate.

15449—No. 17—7

97

APPENDIX B.

BROWN COAL AND WOOD CHAR IN THE FILTRATION OF CANE JUICES AND SIRUPS.

CALUMET SUGAR-HOUSE, BAYOU TECHE, LA.,
Wednesday, February 29, 1888.

DEAR SIR: Pursuant to the conditions attaching 9 tons of German lignite furnished him by the U. S. Department of Agriculture for experimentation in cane-juice filtration at this factory, I am instructed by Mr. Daniel Thompson, its proprietor, under whose exclusive patronage the experiments have otherwise been conducted, to make you the following report concerning the same:

A miniature apparatus comprising mill, steam-defecators, open steam-evaporators, subsidiers, and a laboratory, frame filter-press from Wogelin and Hübner, center-feed, executed in bronze, of one-half square foot filtering area, arranged for complete displacement, offered reasonable facilities at all times to small work. Four Kroog presses of thirty frames, 220 square feet filtering surface each, so mounted with respect to receiving vessels, juice, and lixiviating pumps, safety-valves, and like appurtenances as to have operated upon scums throughout the season without suggesting alteration, besides eliciting the eulogiums of the inventor of the so-called Brown coal process, served during industrial trials. All pipes were of copper or brass, pumps of bronze, and the plates, perforated sheets, frames and other iron parts of the apparatus in contact with juice all thoroughly painted, as insurance against discoloration of products. A well arranged chemical laboratory, unusually well equipped for investigations connected with sugar, was also provided.

Mr. B. Remmers, an English expert in mechanical filtration and sugar refining, well known to readers of the Sugar Cane Magazine, assumed technical control of the experiments, assisted by Mr. R. A. Williams, chemist from the Louisiana Sugar Experiment Station, Mr. J. P. Baldwin, a local adept in defecation, and two long-time employés of the factory.

A preliminary study was made of cake formation. For this purpose Spanish whiting, variously colored, as with aniline dyes and alizarine, kept mechanically suspended in water by vigorous agitation, was pumped into the chambers, the cakes being finished off at high pressures to insure extreme solidity, which, after removal, were cut into sections, longitudinal and transverse. It was found that, with constant or very gradually increased pressures maintained within the chambers, and a liquid kept under unaltered conditions, the cakes formed by extremely uniform accretions, beginning with a thin and even coating of the entire filtering area, over which the various colors used deposited

one upon the other, as fed in succession to the press, in likewise thin and equable layers, until the chambers were quite filled and filtration ceased. With oscillatory pressures and with substances of widely differing specific gravities, such as whiting, brown coal, red lead, wood char, and ultramarine, one following upon the other, the various laminae proved most irregular in their deposition upon the filter-bed, being comparatively of excessive thickness in parts while running out altogether in others, the plane of contact being besides often obliterated or scarcely defined, because of partial intermingling between the different substances employed. The same effects, also, found their cause in the use of any given substance fed alternately in fine and coarse division, or at first in high followed by low percents of the matrix.

There can be little doubt that for the best results in general filter-press work, this indicates, as afterwards substantiated for sugar liquors by the use of hydrostatic columns on the one hand and intermittency secured through means of a by-pass valve on the other, the first importance of constant pressures, freed especially from the vibratory pulsations of ordinary pumps, and a liquid so agitated while awaiting the process as to carry to the press, at all stages of this, a reasonably uniform percentage of whatever matrix is employed, the laws of hydraulics, as illustrated in silt-bearing streams, here again exhibiting themselves in complete application.

Satisfied that the mechanical arrangement of the large apparatus was appropriate to the intervention of a matrix and that the small answered to all the essential conditions of the large, systematic work with brown coal, under what is known as the Kleemann process, began on November 29. Five long tons of this article had been imported by Mr. Dan'l Thompson, through the Sangerhausen Maschinenfabrick, Germany, which, however, was so superlatively unfit for its destined duty, by reason of uneven and inadequate pulverization, as to have required previous and, of course, laborious hand-sifting.

It was first sought to learn what relation varying quantities of this article bore to speed in the filtration of defecated but unskimmed juices. With this intent different percentages, based upon the estimated weight of the contained sucrose, as the most convenient, although not, assuredly, the most rational standard of reference, were employed with the results which follow:

Lignite, per cent. on contained sucrose.	Juice filtered per operation; 30-frame, Kroeg press. (Approximate gallons).		Average time of one operation. (Approximate hours.)		Average juice per press, per 24 hours. (Approximate gallons.)	Average juice per square foot; filtering area per 24 hours. (Approximate gallons.)
	Maxima.	Minima.	Filtering.	Lixiviating and emptying.		
7.5	2,800	2,900	8	3	6,220	28.8
15	2,000	2,100	6	3	5,466	24.6
22.5	1,500	1,600	4.5	2.5	5,396	24.1
30	1,200	1,300	3	2	6,000	27.2
45	950	1,050	1.5	1.5	8,000	36.8
60	700	800	0.75	1	10,275	46.7

The average juice per press and per square foot of filtering surface, per twenty-four hours, stand calculated on the basis of a 60-day continuous run. Here, taking the average weight of the juice at 8.85 pounds per gallon, and its sucrose at 13½ per cent.—for percents of lig-

nite upon sucrose contained may be substituted percents of the same on the weight of juice or pounds of the former per 100 gallons of the latter, as exhibited in the annexed scheme :

Lignite, per cent. on weight of sucrose in juice.	7.5	15	22.5	30.	45	60
Lignite per cent. on weight of juice	1	2	3	4	6	8
Lignite in pounds per 100 gallons of juice.	8.85	17.70	26.55	35.40	53.10	70.80

The juices treated during the interval of this work remained, so far as could be ascertained, essentially uniform as respected adaptability to filtration, as, indeed, they have done up to present writing; being referred in this regard, occasionally, to an arbitrarily selected standard by careful weighings of defecated juice, brown coal, and products operated upon in observed times on tared paper filters. The analyses of raw juices for those dates which cover this series of determinations, as made in the course of diurnal routine work, are presented below.

While they may serve for general comparison with the like as observed in other portions of our tropical cane belt, no relation has yet been noted to exist between the amounts of sucrose, reducing sugars or other known constituents of the juice, and the difficulties exhibited by this in filtration. In the latter regard it is not possible to say if that which has here been experimented upon fairly represents Louisiana's average. It would seem, indeed, to be otherwise, since, in the treatment of scums, great difficulty is reported to have been experienced in almost, if not every, other local factory possessing filter-presses, while at this no other process of manufacture was throughout so satisfactorily performed.

Date.	9 a. m.				3 p. m.				9 p. m.			
	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.	Solids.	Sucrose.	Glucose.	Exponent.
1887.												
Nov. 30	15.96	13.5	1.45	84.58								
Dec. 1	15.03	12.0	1.31	79.84	15.23	11.6	1.25	76.16	15.43	12.0	1.14	77.77
2	15.30	12.1	1.27	79.08	14.78	11.0	1.09	74.42	14.43	11.7	1.33	81.08
3	15.27	12.3	1.52	80.55	14.07	11.2	1.47	79.60	13.78	9.7	1.56	70.39
5	14.09	10.4	1.62	73.81	14.09	10.7	1.50	72.83	14.91	11.5	1.36	77.12
6	14.18	10.1	1.50	71.22	14.03	11.0	1.43	78.40	14.23	11.2	1.36	78.70
7	14.06	10.8	1.45	76.81	14.58	10.7	1.50	73.38				
8	14.43	11.5	1.66	79.69	14.77	11.5	1.51	77.86				
9	14.63	11.7	1.56	79.97	14.69	11.3	1.38	76.92				
10	13.96	11.3	1.48	80.94	14.09	11.5	1.47	78.28	14.96	11.4		76.20
12	15.09	11.7	1.64	77.53	15.63	12.1		77.41	14.00	11.6		82.85
14	14.17	12.1	1.61	85.39	14.93	12.1	1.66	81.04	14.20	11.3		79.67
15	15.03	11.9	1.47	79.17	15.09	11.8		78.19				
16	14.63	12.5	1.66	85.44	14.09	12.9	1.43	87.81				
17	14.97	12.0	1.64	80.16	14.69	13.4	1.45	91.21				
19	15.16	12.3	1.35	81.13	15.43	12.6	1.34	81.65	15.29	13.6	1.22	88.94

Average solids	14.72
Average sucrose	11.68
Average reducing sugars (glucose)	1.44
Average coefficient of purity (exponent)	79.34

Plant cane, 27.5 tons (*circa*) per acre, blown prostrate September 16.

From these trials the resulting extremes, in round numbers, have alone been given. Variations in temperatures and in pressures, both with juice and displacement water; in density and completeness of defecation with the former; in perfection of cake and lixiviation sought, as in other similar variables, some premeditated, others at times uncontrollable, render, as will be understood by a trained experimentalist like yourself, absolutely definite and thoroughly iron-clad figures quite out of the question. The average amounts of juice put through given filtering areas in fixed times have, however, in fact, most nearly corresponded with those presented as minima.

In general, it may be safely said, the most satisfactory filtrations were uniformly of juices slightly acid only, 180° F. (*circa*), under pressures which, initially low, were most gradually increased until, at finishing-off, 60 pounds per square inch had been attained. Neither reasonable increase of pressure nor higher temperatures than these availed perceptibly. Boiling after the addition of the lignite produced no good result later in filtration, when intimate admixture of matrix and liquid had been maintained. Of displacement, or the depletion in sugar of the cake, more will be said hereafter.

Utterly at variance as the coal percentages and time volumes indicated are with promises which had preceded the process to this country, they proved as persistent as they are disappointing. From 30 to 45 per cent. on the estimated crystallizable product present were shown over and over again to be the smallest of coal consistent with reasonable amounts of work done in given times, with given filtering areas, whether by the experimental or the working apparatus. Upon this last from one to three consecutive defecators, of exceeding 1,300 gallons each, were repeatedly essayed. Separate treatment of skimmed liquors and their scums did no better in the aggregate. Those substances which peculiarly interfere with filtration appear to be removed only in minimum degree with the skimmings and sediments. Were this otherwise, separation and recovery of juice from the latter by filter-pressing, as now practiced, would scarcely be feasible. It was the same whether with a lime, a sulphurous acid and lime, a lime and phosphoric acid, an acid sulphite of alumina, or an acid albumen defecation, under the Willcox patent; and with these reagents in all proportions. Tannic acid extracted coloring matter from the brown coal, as did phosphoric and some other chemicals, without facilitating filtration. The use of lignite in alkaline solution is forbidden by its solubility in such. Basic lead acetate showed no better effects with the small press than the rest. Carbonatation alone succeeds, and this, as you told me, requires no lignite. Repetition, later repeated, with foreign lignite prepared under Mr. Kleemann's individual supervision and furnished by your department, as also with native coals obtained from the Louisiana Sugar Experiment Station and other sources, comminuted at home, aggravated the disappointment. All degrees of pulverization were tried. The amounts filtered seemed tolerably constant for stubble and plant-cane juices and for juices from freshly cut canes, and from those many weeks windrowed. From old land cane they did doubtfully better than from new; those deteriorated as a frost effect not altogether so well, perhaps, as those not so injured. With cane freed from its adhering *cerosin*, by sand-papering prior to crushing, it went no better. Butts showed no decided superiority to middles and tops.

In all cases the filtered juices, whether from skimmed liquors or scums or the two treated without previous separation, whether from high or low percentages of brown coal and with whatever defecating agent em-

played, were exceedingly bright and clear from the first until running had quite ceased altogether. Another disappointment, however, awaited inquiry into the actual improvement as to purity secured. The exponent, on the average, was raised not materially to exceed one per cent. of total solids attributable to the coal, exclusive even of sweet-waters. A few analyses, taken at random from the laboratory records, sufficiently illustrate this. In every case the non-filtered and filtered samples represent, as nearly as practicable, the same juice. For the large presses these were taken in equal volumes at the discharge openings of defecators and presses, respectively, at intervals of three minutes, always so as to represent by pairs identical defecators of juice and identical defecations, before and after filtration, which, following adequate admixture of each series, as obtained from individual defecators, were re-sampled. This was permitted by the admirable arrangement of the coal-mixing receivers, which contained, each, precisely the amount from one defecator, and which were filled and emptied alternately in rotation. The effect of a thorough cake washing, the sweet-water being mixed back proportionately with the filtered juice, of which it was the after-product, is shown in the last two analyses.

Date.	Defecated, not filtered.					Filtered, 80 to 45 per cent. brown coal.					Improvement in exponent.	Remarks.
	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.		
1887.												
Dec. 28	16.44	13.0	1.84	79.08	14.15	16.43	13.3	1.80	80.95	14.15	1.87	Frosted cane.
28	16.44	13.0	1.84	79.08	14.15	16.03	12.9	1.78	80.47	13.79	1.89	Cake from the above used.
29	16.44	13.6	1.48	82.72	10.70	16.44	13.8	1.38	83.94	10.00	1.22	
30	17.05	13.9	1.25	81.52	8.99	16.48	13.6	1.19	82.53	8.75	1.00	Willow albumen defecation.
31	15.00	11.7	1.44	78.00	12.30	14.70	11.6	1.40	78.91	12.07	0.91	
1888.												
Jan. 2	15.00	12.6	1.20	84.00	9.52	15.30	13.0	1.30	84.97	10.00	0.97	
3	15.17	12.8	1.07	81.08	8.69	15.20	12.6	1.10	82.89	8.00	1.81	
4	15.11	12.3	1.19	81.40	9.67	14.56	12.0	1.18	82.41	9.41	1.01	
10	16.46	13.5	1.00	82.01	7.41	15.96	13.3	1.01	83.33	7.52	1.32	Large presses, Willow defecation.
17	16.44	13.5	1.10	82.11	8.17	15.12	12.6	1.02	83.33	8.09	1.22	Large presses, lime defecation.
17	16.63	13.6	0.96	81.77	7.06	15.67	12.9	0.83	82.52	6.43	0.55	Large presses.
17	16.47	13.5	1.00	81.96	7.40	15.57	12.8	0.89	82.21	6.95	0.25	Large presses, pro rata of sweet H ₂ O included.
17	16.36	13.6	1.06	83.12	7.79	15.29	12.9	0.94	84.37	7.28	1.25	Large presses.
17	16.36	13.0	0.91	79.46	7.00	15.34	12.2	0.83	79.53	6.80	0.07	Large presses, pro rata of sweet H ₂ O included.
17	15.90	13.4	0.98	84.27	7.35	14.78	12.5	0.90	84.57	7.20	0.30	Do.
Means.	16.03	13.1	1.22	81.46	9.31	15.52	12.6	1.16	82.47	9.06	1.01	

After that, due to the use of 10 or 15 per cent of lignite on the weight of sugar present, no commensurate effect was observed to be produced in the direction of increased purity by the addition of further quantities. This fell off very slightly or not at all, however, as filtration proceeded towards its finishing point, as also more or less in lixiviation, depending, as seemed shown, upon a lower or higher percentage of coal employed. Believing the application of the process to Louisiana juice, condemned by the excessive quantities of lignite found essential to sufficiently rapid filtration and by its failure to realize a higher gain in purity, before reaching conclusive knowledge of these minutiae it

should be said these have not since been accorded that systematic inquiry which, otherwise, they would have deserved.

As decolorizers of saccharine liquors, either dilute or concentrated, certain brown coals are, on the other hand, surprisingly effective. In the table annexed are given to the nearest per cent. the color repeatedly removed from defecated juices, by varying percentages of the article furnished by your Department, referred in each series to standard samples prepared from the defecated juice dealt with by mere passage through filter paper. This paper filtration is a necessity, since suspended matter, lighter in color than the mother-liquor, partially by preventing the transmission of light through this last and partly by itself reflecting light, gives invariably, in simply subsided juices, a tint too light by a number of degrees. The percentages of color removed were uniformly measured by the relative length of columns made to give the same tint as the untreated standard when contained in tubes of like glass, of caliber such as to avoid a decided meniscus, and with light of equal intensities transmitted from below in lines parallel to the columns' longitudinal axes.

Lignite, per cent. on weight of sucrose.	Length of columns mm.	Per cent. color removed.
Unfiltered	10	-----
5	28	64
10	36	72
15	50	80
20	64	84
25	80	88
30	92	89
40	100	90
50	112	91

In the foregoing the juices were treated nearly to neutrality with lime alone. With sulphurous and phosphoric acids, acid albumen, acid sulphite of alumina, or even a decidedly acid lime defecation, the percents. removed were, of course, reduced, there being a less intense primary tint. No other lignite gave such high effects as that furnished by your Department. This will be seen from the accompanying approximations, obtained with from 22.5 per cent. to 25.0 per cent. of lignite on the weight of sucrose filtered, expressed in maxima and minima to the nearest 10, sulphur fumes having been used on the juices—the sirups not having been treated with coal prior to concentration.

Lignite, where obtained.	Per cent. color removed.			
	Juice.		Sirup.	
	Maxima.	Minima.	Maxima.	Minima.
Sangerhausen Machine Works, Germany	60	40	45	35
United States Department of Agriculture, prepared by F. Kleemann, Germany	80	60	50	40
Louisiana Sugar Experiment Station, mined in Alabama	70	50	45	35
J. B. Friedheim, Camden, Ark.	60	40	40	30
B. F. Read & Co., Mineola, Tex.	60	40	40	30

The higher effect of your article is perhaps attributable, in considerable measure, to a more perfect pulverization than that secured in other samples, the degree of this exercising an undoubted influence. As was noticed in the matter of purity coefficient, after the use of some 15 per cent further amounts added were out of all proportion to the increase in effect. The power of lignite to absorb or otherwise destroy or remove is apparently confined to those contained substances producing particular color effects only. For these its affinity is certainly very great, animal char or bone black, in the lower percentages, being found altogether out of comparison with it in this regard. These colors suppressed, however, by a relatively small quantity of the lignite, additional quantities produce but little useful effect, the remaining coloring matters being those for which it possesses little or no affinity. This hypothesis explains the fact that, having used so much as 30 to 45 per cent. to secure rapidity of filtration, the cake from one operation was found to have lost none of its decolorizing power upon a second application, though it no longer filtered with the same efficiency. Its influence upon the exponent, also, seemed to have diminished little by like previous use upon juice, although considerably more so after the filtration of dense sirups not first treated as juice, a fact possibly finding its explanation on the same lines. Except for the Texas sample, all the coals examined gave up a slight amount of greenish coloring matter, whether boiled in distilled water, juice, or sirup, all showing likewise an acid reaction, your own being most pronounced in the latter particular.

A hard and apparently very dry cake was obtained with whatever variety of lignite, if employed in amounts above 15 per cent. of the contained sugar, provided only ample time was accorded its formation. It was, however, in all instances of high per cents, exceedingly porous as compared with scum cake finished off at corresponding pressures, weighing per press always in close proximity to the ascertained average of 670 pounds at a final pressure of 60 pounds, of which, after lixiviation at 40 pounds pressure, 49 per cent., a little more or less, was moisture.

Since with a juice polarizing 13 per cent. sucrose some 46 pounds of the latter would be otherwise lost from each pressing, equal to nearly 3 per cent. of the entire amount treated, supposing 1,300 gallons of juice to be put through, with 30 per cent. of the brown coal, at each operation, the importance of lixiviation can scarcely be overstated. No press except arranged for this supplementary process in its most complete attainment would, of course, be admissible. This work is too ununiformly accomplished by steam, by reason of channels at once cut on lines of least resistance, which, besides, leaves the press too hot for immediate manipulation and severely taxes the cloths. Hot water results in too rapid and too great a reduction of the purity coefficient, possibly because of the action of heat upon the solubility of some among the retained impurities. Cold water certainly performed best, all things considered.

The theoretical amount of so-called displacement water was found altogether inadequate. For a 30-frame Kroog press 200 liters are, for reasons not necessary to state, supposed to be the extreme limit of requirement. This amount when passed in one hour—already a serious loss of time compared with the filtration itself, which consumes but three with 30 per cent. of coal—gave at finishing-off a sweet-water still running at an average analysis of: solids, 6.77; sucrose, 5.0; reducing sugars, 0.52; exponent, 73.87. Assuming the 49 per cent. of retained moisture

on the 670 pounds of cake to be juice diluted to the same figures, we should have:

	Pounds.
As water	328.70
As contained solids	23.83
As dilute juice	352.13

equal to 25.5 per cent. of the cakes' weight, which would mean the loss per operation of $670 \times 0.525 \times 0.05 = 17.58$ pounds sucrose, or $352 \times 0.05 = 17.60$ pounds sucrose, or to $17.60 \times 46.1 = 811.36$ pounds sucrose per day's work of 60,000 gallons of juice, using 30 per cent. of lignite.

As a matter of fact, analysis of the cake showed this to contain 2.8 per cent. sucrose, or 18.76 pounds, of the latter per pressing—a seeming paradox, dispelled by physical examination. This sufficed to reveal how the water, first finding its way past the cake on its line of contact with the iron frame, thoroughly lixiviated the extreme peripheral portions of this, afterwards to pass here in important volumes without effecting any good purpose, while yet having accomplished only a very partial depletion of more central parts. Here was met the third and last serious technical objection to lignite; one which, since it is multiplied by the number of pressings required for given volumes of juice filtered, must apply to the use of any matrix just in proportion as larger or smaller amounts of this are essential to the results sought.

There appeared to offer two methods of escape from this difficulty, each, however, involving a dilemma. Lower lixiviating pressures, while producing much better effects, prolonged the time required for the operation so far beyond the reasonable as would need double or treble the filter-press plant. Increased quantities of water employed reduced the exponent, prolonged the time, and increased the evaporation correspondingly. A third expedient was less effective, but offered some collateral advantages, to wit, more perfect pulverization of the matrix. There can be no reasonable doubt that the finer the state of division to which brown coal is reduced the more rapid becomes filtration, the more complete the decolorization effected, the more solid its cake, and the lower its final per cent. of retained juice. Sifted through the finest of millers' silk bolting-cloth, it performs better duty in every respect than otherwise. It is advisedly stated, and with positiveness, after repeated experiment, that lignite can not be too finely prepared, on a large scale at least, for cane-juice filtration, by any mechanical means at present command. Dissolved even in strong alkalis and reprecipitated as an impalpable powder, its efficiency is yet further enhanced.

As a last recourse higher juice pressures, even up to 300 pounds per square inch on the small press, were used. This, though it unquestionably left remaining a cake charged likewise with less juice and so uniformly compact as to be better adapted to displacement, again was attended with too serious a loss of time, both in finishing off and in subsequent lixiviation, to compensate the advantage in sugar redeemed or evaporation avoided. Pressures in excess of 100 pounds per square inch are, besides, not feasible in industrial practice.

A single industrial run of twenty-four hours was finally made January 16th and 17th with brown coal, with intent primarily to develop and locate any unforeseen mechanical difficulties incident to continuous work. Numerous such arose, of course, each happily, however, suggesting at once its own certain remedy. If, technically, this large effort was not as satisfactory as might have been anticipated from the painstaking arrangements made for and well-organized and precise management ac-

corded it, it was yet successful beyond all expectation in solving those problems which must ever attach in cane-juice work to the application in filter-presses on a considerable manufacturing basis, of any matrix whatever. It removed at a stroke all necessity for the yet more extensive operations which, as you know, had previously been proposed.

It is needless here to weary you with the details of this day's run, which, with its antecedents rather than with its consequents, demonstrated conclusively, as is believed, that while the filtration of the entire body of defecated juice thus, with brown coal, stands well among the mechanical possibilities, its application can by no means now conceived with us be rendered remunerative to the Louisiana industry. This your discernment will already have made quite as clear to you by what precedes, as it can by any present comparison between the weights and polarizations of its resulting products and those customary to the establishment in its treatment of like raw materials. Such data, indeed, await your command, but indicate to me no variation in *rendement* beyond that attributable to the accidents and incidents common with every-day factory experience. There occurred nothing of the oft and persistently predicted clogging, either of pumps, conduits, presses, or cloths. The cloths at the end of twenty-four hours showed no loss of transmitting power, and were washed with surprising ease.

In quality of products, no doubt, some advantage was recognized to accrue, bone-coal not being employed in the factory. Notwithstanding, in this particular also, disappointment was felt. In no other respect than this, surely, did the results of this experiment compare even favorably with those secured by Mr. G. L. Spencer, in 1886, with the Reimers and Williamson wood-char process, under the patronage of your Department at its Magnolia Station, as these stand officially reported in your Bulletin No. 15 (pp. 20-25, inclusive). So much more effective has vegetable char than brown coal been shown also in our own work, both as a filtering and as a defecating agent, that, having abandoned the latter altogether, experimentation since several weeks with the former, in a laboratory way, with seed-cane, has now been in seemingly successful progress here. The following is not an unfair comparison, so far as experience yet teaches, between the two articles applied to juices somewhat deteriorated by long storage of canes:

	Matrix required on weight of su- crose.	Improvement of purity coeffi- cient.	Decolorization sulphured.
	<i>Per cent.</i>		<i>Per cent.</i>
Brown coal	30 to 45	0.30 to 1.90	80 to 80
Wood char	6 to 12	1.50 to 4.30	6 to 12

Lignite presents other disadvantages, as well, in comparison with wood charcoal. Upon concentration to sirup, juice filtered with whatever percentage of it, whether reduced with the low temperatures of vacuum evaporation or under atmospheric pressure, gives invariably an additional precipitate of matter probably rendered insoluble solely by the increase of density. No such precipitate has at any time, with any defecating agent, been observed after filtration with wood coal. How weak is its absorptive power, beyond that for coloring matters, is shown by the fact that, after filtration through paper alone, an improvement of but 0.03 in the exponent was secured to sirups from the ordinary lime

defecation by subsequent treatment with 30 per cent. of the lignite. Below are the averages:

[Concentrated in double effect.]

Sirup.	Solids.	Sucrose.	Glucose.	Exponent.	Glucose ratio.
After primary filtration through paper	57.60	47.2	4.55	81.94	9.64
After subsequent treatment with 30 per cent. lignite ..	62.70	51.4	4.76	81.97	9.59
Rise in purity coefficient with lignite				0.03	

Although when freshly ground, and yet containing from 30 to 35 per cent. of hyroscopic moisture, it can be readily brought to mix intimately by mechanical means with the juices, this is scarcely to be accomplished in the large and regular quantities required if, having been long prepared, desiccation to 15 or 20 per cent. has not somehow been prevented; in which state, if sufficiently comminuted, it excels not only the kneading requirements of patent flour fourfold but becomes even dangerous from liability to spontaneous combustion. This infers the necessity for a grinder on the premises, with engine, foundations, sifters, elevators, mixers, shafting, belting, and their like *ad libitum*, in a structure apart from the factory building proper, which last would needs be protected from the attendant dust, as another serious sugar-making complication and care. Such a plant has been estimated, by a probably competent European engineer, to cost, for a 60,000-pound diurnal output, erected upon this property, exclusive of the presses and their immediate appurtenances, but inclusive of building, not less than \$10,000. Wood coal can, on the other hand, safely be prepared during the leisure of idle months, at home or elsewhere, and be mixed in the greatly reduced amounts called for, as wanted, with the most simple and inexpensive devices or be stored without injury or danger from season to season. Even wood char, however, for satisfactory filtration, should also contain a considerable percentage of moisture when ground. Otherwise the first run of liquor is likely to come charged with the char, requiring refiltration. It appears that this, unlike lignite, may be rendered in part too pulverulent, which last the enforced presence of sufficient moisture at the time of its reduction is believed to prevent.

Brown coal, again, is not known to exert even a favorable mechanical action on the soil's productiveness; that wood char exercises valuable functions in this regard is well understood among agronomists. If in the ordinary filter-pressing of scums and sediments well-nigh the entire fertilizing content of the juice itself is already secured, leaving no credit for such properly to be conceded to either, for this mechanical advantage of charcoal something may well be deducted from its estimated first cost to manufacture. It presumably absorbs from the juice, also, fertilizing material in excess of the brown coal, equivalent to the additional rise it secures in the exponent of this. The aggregate bulk of brown coal required would be such as might well preclude economic distribution over the fields.

Considering the quality of the native brown coals as yet examined, the cost of transportation, and, if imported, the duty upon such enormous quantities of these as are demanded, the price of vegetable char, it appears, should compare most favorably with them throughout the

Louisiana sugar belt. Brown coal, in sugar work, demands also a royalty under letters patent; the patents upon wood char, in this application, have been permitted to lapse. Brown coal can not be revived. Wood char, it is believed, can be reburned by superheated steam in any state of comminution, if found desirable. It remains to be known from the distillation of which variety of wood, however, the best quality of the last-named article for the purpose proposed is to be obtained. As saw-dust, oak is known to perform best, probably because of its excess in tannic acid.

As of application with whatever matrix employed it is pertinent only to add, as a further result of our experience in the matter, a few convictions touching the appliances best suited to the treatment of juice in considerable volumes.

The advantage of duplex, double-acting plunger pumps, extra large for their duty and operated at low-piston speeds, with exceedingly capacious air vessels and sensitive safety-valves placed close to the pumps, the last of equal conducting capacity with the feed-pipes, was fully indicated. To thus insure, by every means, against sudden variations of pressure, such, especially, as the vibratory pulsations inseparable from ordinary pumping plants, seemed essential to a cake of maximum uniformity and uniformly well adapted to lixiviation in all its parts, as before insisted. With the lixiviating apparatus itself this completeness in erection is even more prominently to be indorsed, except that, as no grit is here to be encountered, piston-pumps should suffice. A continuous stream of liquid running from the safety-valves, both juice and lixiviating, should be maintained during operation. In the most perfect practice no approach to theoretical displacement has been found to occur. This supplementary process is, unfortunately, at the most we have been able to make it, little more than has been expressed with the word lixiviation. Whiting and highly colored liquids render its study facile.

The absolute necessity to the process of chamber presses, whether top, bottom, or central feed, and, conversely, the total unsuitability of frame-presses in general to it, was left in no doubt. Each operation consumes so short an interval that a large percentage of total time is spent in emptying. A chamber-press can be emptied readily in one-half the period consumed by one of the frame variety for the same number of cakes. As the cloths need be removed not oftener than twice a week the loss from this source, in employing such, is negligible. It is not true that cloths wear most rapidly from use in chamber presses, except these be ill-constructed. The tendency during lixiviation which the water exhibits, however this be fed and no matter how superlatively perfect the cake is, to cut of itself a ready and continuous channel about the cake's peripheral joint with the iron frame, has been mentioned. This results in a sludge formed along the cake's feather edges which, upon opening the press, runs more or less, despite the best effort, down the frame's sides, especially along its bottom portions, compromising the joint which this afterwards makes with its adjoining cloth. Following three rounds with brown coal, such a press can not be made tight and after four or five may even refuse to close, except the surfaces be laboriously cleansed with iron scrapers. In chamber presses the peripheral joint is made between cake and cloth and not between cake and iron. From this fact alone it is far more perfect. Its form, however, if properly designed, is of yet greater importance and, presenting no longer necessarily a line of least resistance, reduces the chance of sludge, besides insuring, other things equal, a more uniform and complete dis-

placement with reduced quantities of water by preventing the formation of such water channels as those before described. If, by any chance, a small amount of semi-liquid material here runs in like manner, notwithstanding, this interferes in but half degree with a press joint now made between two thicknesses of the fabric instead of between iron and one such. Although in top and bottom fed chamber presses the liquor inter-ports of the individual chambers may be of greater diameter than those possible with frames, yet from liability to obstruction the center feed is to be preferred.

Any filter-press constructed for the use of brown coal or any of its congeners should be recessed for $1\frac{1}{2}$ instead of for 1 inch cakes. This statement will not remain true except that in all cases the wisdom of employing the matrix in excess is confirmed. A yet greater thickness in these might then perhaps prove still more advantageous were it not the limit at which, in such presses, the cloths have been made to stand. Without attempting an explanation of the fact it remains that with chambers of increased thickness higher results per square foot of filtering area are attained, this dimension even doubled, curiously enough as it would seem, requiring but a very small fraction more of time for cake completion than before, so long as a slight excess only of matrix is in each instance employed. This is best illustrated in starch manufacture. Speed in filtration is, then, increased by this innovation, except for deficiency of matrix; a relative reduction in the amount of sweet-water to be dealt with is secured and proportionate time is saved in emptying.

Since it consumes no more time to empty thirty chambers presenting 400 square feet of filtering area than thirty aggregating but 220, presses of the former size should alone be used for the purpose under consideration. Such are decidedly cheaper in first cost per square foot of filtering surface; are as readily handled and kept tight, and require, proportionately to the work done, fewer laborers. They occupy scarcely more space.

The presses should be worked in batteries after the English plan, instead of by rotation, as practiced in Germany. This avoids a fall of pressure, with consequent loss of time and a cake ill suited to lixiviation in the other active presses, when one freshly prepared is set in operation. It also permits, which is of much consequence, low pressures at the start, which are gradually increased to high at the finish—a practice precluding all attempt at governing the pressure at the pump's throttle by an attached pressure regulator.

A precipitate invariably following evaporation, by whatever means accomplished, of juice filtered through brown coal, the filtration of sirup was accorded some study. For this purpose from 12 to 15 per cent. of lignite on the weight of sugar operated upon was found necessary to satisfactorily rapid work, previous treatment notwithstanding. Again the improvement in purity was not marked, averaging 0.82; that in color being the more conspicuous result, at about 40 per cent. of this removed.

For sirups from unfiltered juices the ratio of lignite had, of course, to be increased until percentages approaching those employed with juice had been attained. Equal amounts would probably have been necessary, in terms of sugar, except for scums removed and some 8 to 10 per cent. of the juice itself already filtered with these, decantation of clear liquor from skimmings not having been practiced. Mere bulk, thus, in the filtrate, was seen to exercise no perceptible influence in this work. The dilution of sirup by the addition of water in any amount can, of course,

in no wise reduce the quantity of coal required, which is determined alone by the quantity and quality of non-sugar dealt with. Neither the net result in purity nor in color was equivalent in filtered sirup from unfiltered juice to that secured in unfiltered sirups from filtered juice. The glucose ratios of sirups first filtered as such were always considerably higher than those of unfiltered sirups derived from filtered juices of like quality. It is supposed that by the filtration of juice—though this is left in all cases more acid by the process—certain active inverting agents are removed, thus reducing the losses otherwise sustained in concentration. The brown coal also removed an amount of reducing sugars relatively larger than that of sucrose lost in the operation, the glucose ratio being almost uniformly lower after than before filtration, whether of juice or sirup. The ash is also reduced.

Not above 550 gallons of sirup from unfiltered juice could be put through a 30-frame Kroog press with 25 per cent. of brown coal on the weight of its sucrose at one operation, this, complete, occupying about four hours. A $\frac{7}{8}$ -inch frame or chamber was found ample in the treatment of sirups, but even for this work 400-foot presses, it is thought, would be preferred. Thinner frames would be necessary with reduced percentages of lignite. Lower pressures than those mentioned for juice gave the more satisfactory results, which, also, should be extremely steady.

The cake from sirup filtrations following that of the juice, with or without lixiviation, when mixed with the amount of fresh coal necessary to bring the total of this to the usual standard, was found to perform about as well on a fresh supply of juice as an equal total of fresh coal, the amount of the latter being thus proportionately reduced. In practice this would obviate the difficulty of sweet water from the sirup filters. Wood char was given no trial in connection with concentrated liquors. The whole subject of sirup filtration, in filter presses, merits more thorough investigation than circumstances have yet permitted at this factory, although success with such can scarcely supplant the far greater necessity for previous treatment of the juices.

Experiments, by no means exhaustive, were also made with the Bauer process. This failed from the first. The mucilaginous impurities, passing through the interstices of the bone-char, reached and occluded at once the pores of the cloth, thus bringing operations to a speedy termination with every trial. The cloths were washed with great difficulty. To fully meet every prejudice, the entirely inutile use of various fabrics was resorted to. With bone-black, from coarse to finest, the result was always the same. Indeed, as is well known, animal char in sugar work is an extremely poor filtering medium, no matter how skillfully revivified, and except for the preliminary Taylor or bag filtration could scarcely be used after the manner or in the per cents. at present common, except upon the highest centrifugal goods, even in the refining of sugars from which the major portion of non-sugar has already been removed, upon the plantation, in scums, sediments, and molasses—substances which are yet left remaining with us in our treatment of juices. It is imperative with this article, in our work at least, that it be used in quantities quite beyond the utmost ability of filter-presses to accommodate.

Notwithstanding the meager results as yet secured, eventual success in the economic mechanical filtration of the entire body of defecated juice is not altogether despaired of. Its difficulties have been greatly underrated. All the juices thus far dealt with have been the product of milling under pressures attaining from 65 to 78 per cent.

of these upon the weight of canes crushed. So successful throughout has been the routine work in this establishment with skimmings and settlings from all manner of canes and with many modes of defecation, and so small has been at any time the immediate improvement in the purity co-efficient attributable to it, and yet, by comparison, so easy and rapid a second filtration, as to have forced a conviction that in but an exceedingly small part of the total non-sugar residues well nigh the whole difficulty. This probably minute portion of especially refractory material has been traced, as an insoluble, suspended impurity, to raw juice direct from the rolls, which presents in the filter practically all the perplexities encountered after defecation, and may be followed thence quite to the molasses. The microscope has not identified it at 100 diameters. Fermentation fails to remove it. Although itself probably inert and harmless, it suffices to render most difficult or altogether impossible a process which, in effecting an immediate improvement, if only of several points in the exponent, would yet suffice before the by-product was reached to add directly or indirectly a decided increment to the otherwise possible *rendement*. Your success in filter-pressing carbonated diffusion juices this season of 1887-'88, at the Magnolia Station, leads to the hope that this small part, whatever it may be, is either in great measure eliminated from the artificial juice by diffusion, or else is amenable to chemical treatment (other than carbonation), such as it is reasonable to suppose will not escape adequate research. In either case the benefit to accrue would become important to the local industry, the substitution of osmosis for pressure in juice extraction by large central factories now seeming as if eventually inevitable.

It is proposed by the proprietor that the investigation of this subject shall continue at this place uninterruptedly throughout another season. At his desire I express the hope that it may not be impossible with you to detail a chemist from your department to aid in this search for an improved defecation. It is not to be overlooked how, to the present, your department, in pursuing its inquiries with respect of sugar manufacture, has neglected altogether the sulphur regimen universally found in Louisiana's practice, excepting only at its previously chosen station.

With much respect, sir, I am yours, very truly,

W. J. THOMPSON.

Dr. H. W. WILEY,

*Chemist, U. S. Department of Agriculture,
Washington, D. C.*

ILLUSTRATIONS.

FIG. 1. Ensilage cutter used at Fort Scott for cutting cane into convenient lengths for cleaning.

FIG. 1 (bis). View of cutter used at Fort Scott for preparing the pieces of cane after cleaning for the diffusion battery.

FIG. 2. View of the top of the battery at Fort Scott.

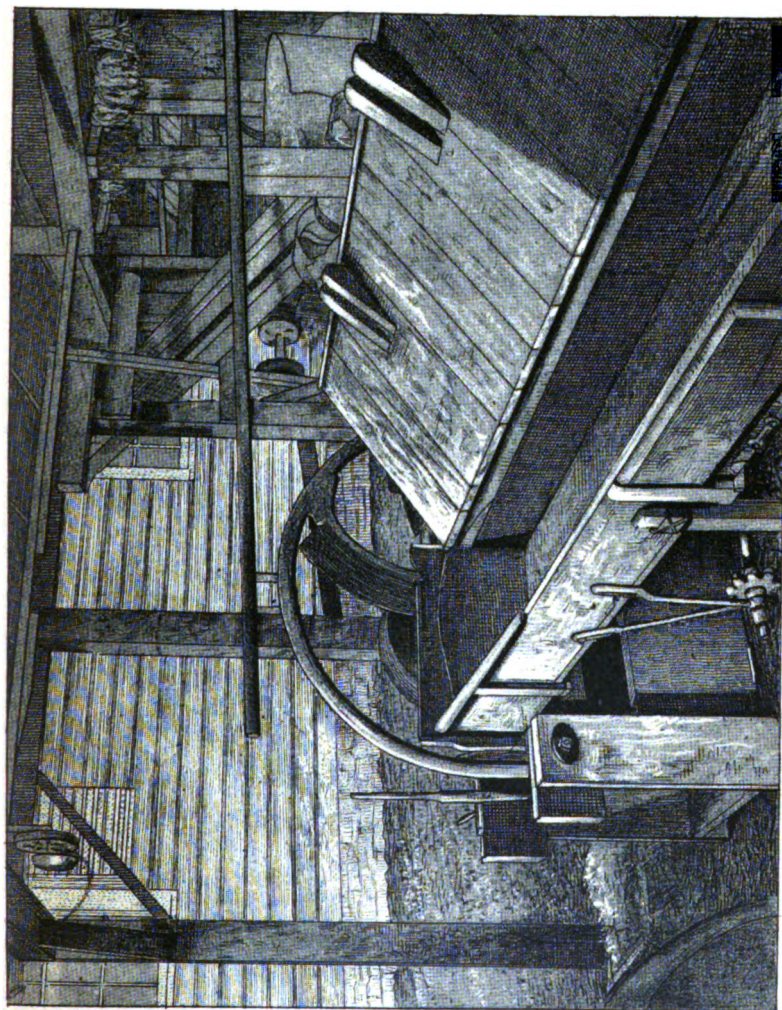
FIG. 3. View under the battery at Fort Scott, showing car for removal of exhausted chips.

FIG. 4. Outline of apparatus used for cutting and cleaning cane and preparing it for diffusion at Rio Grande, New Jersey.

FIG. 5. View of diffusion battery used at Rio Grande, New Jersey.

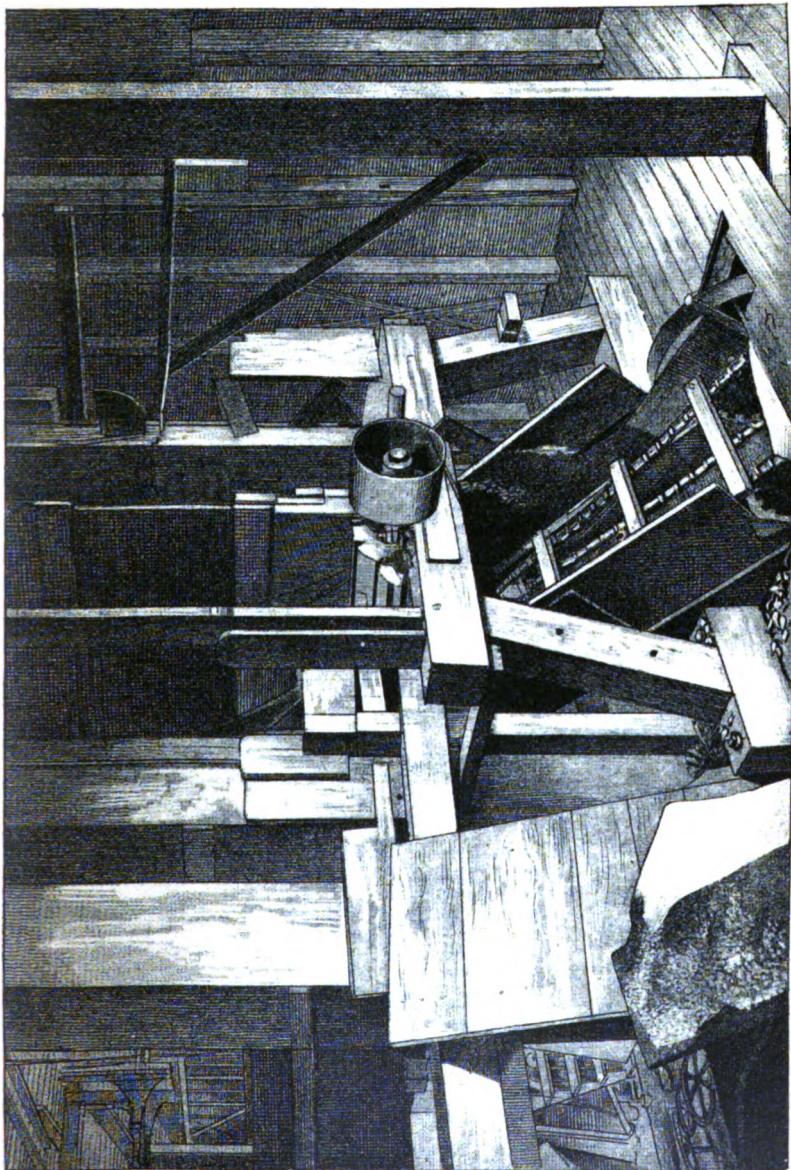
15449—No. 17—8

113



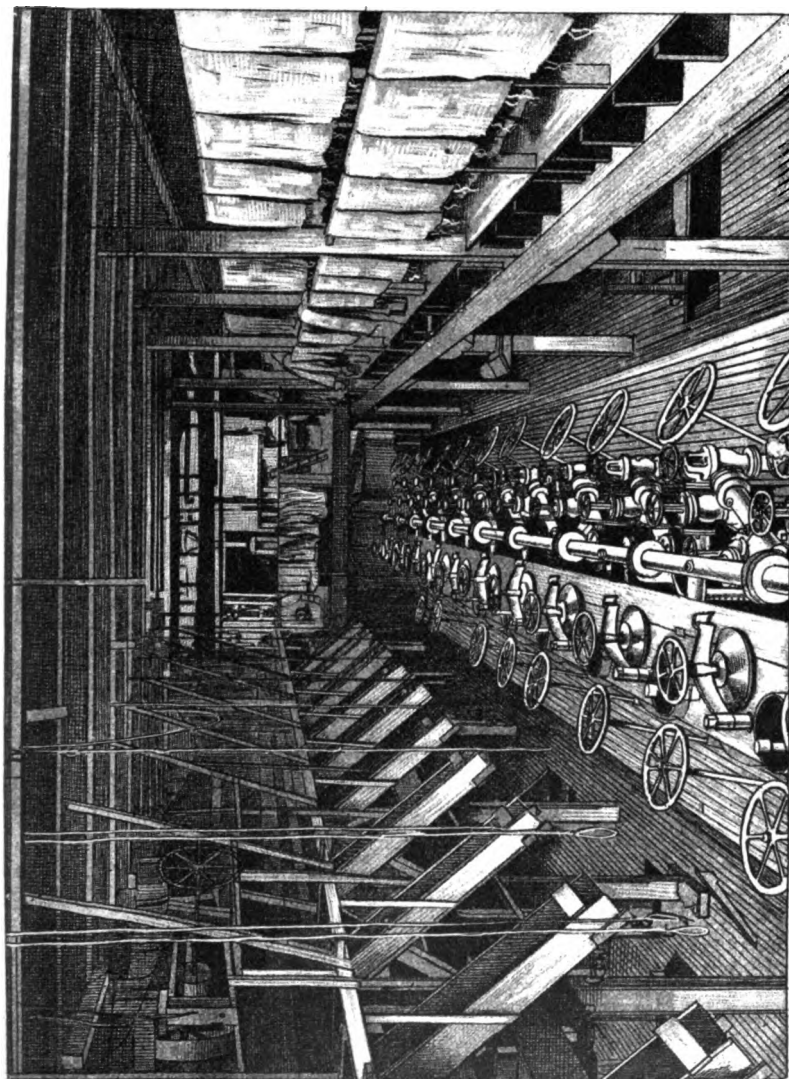
A. Brown & Co. Lith. Baltimore

CUTTER.



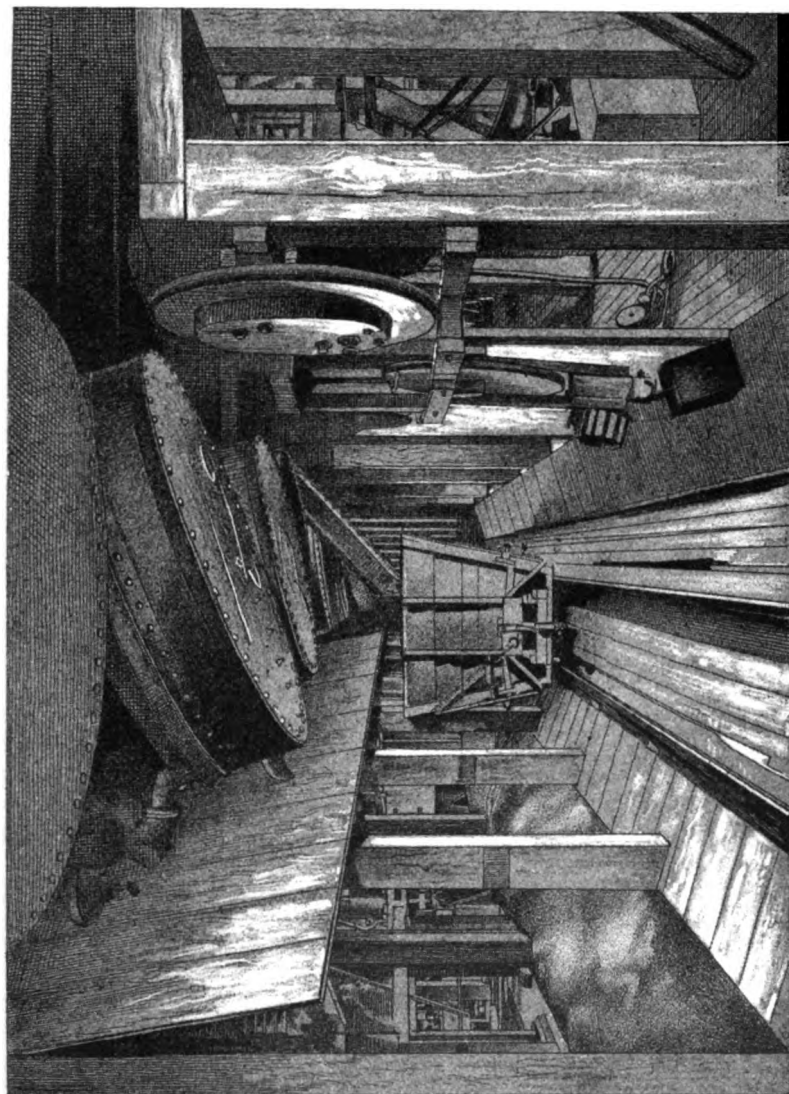
A. H. HARRIS & CO. LONDON, ENGLAND

CUTTER



A. Brown & Co. Lith. Baltimore.

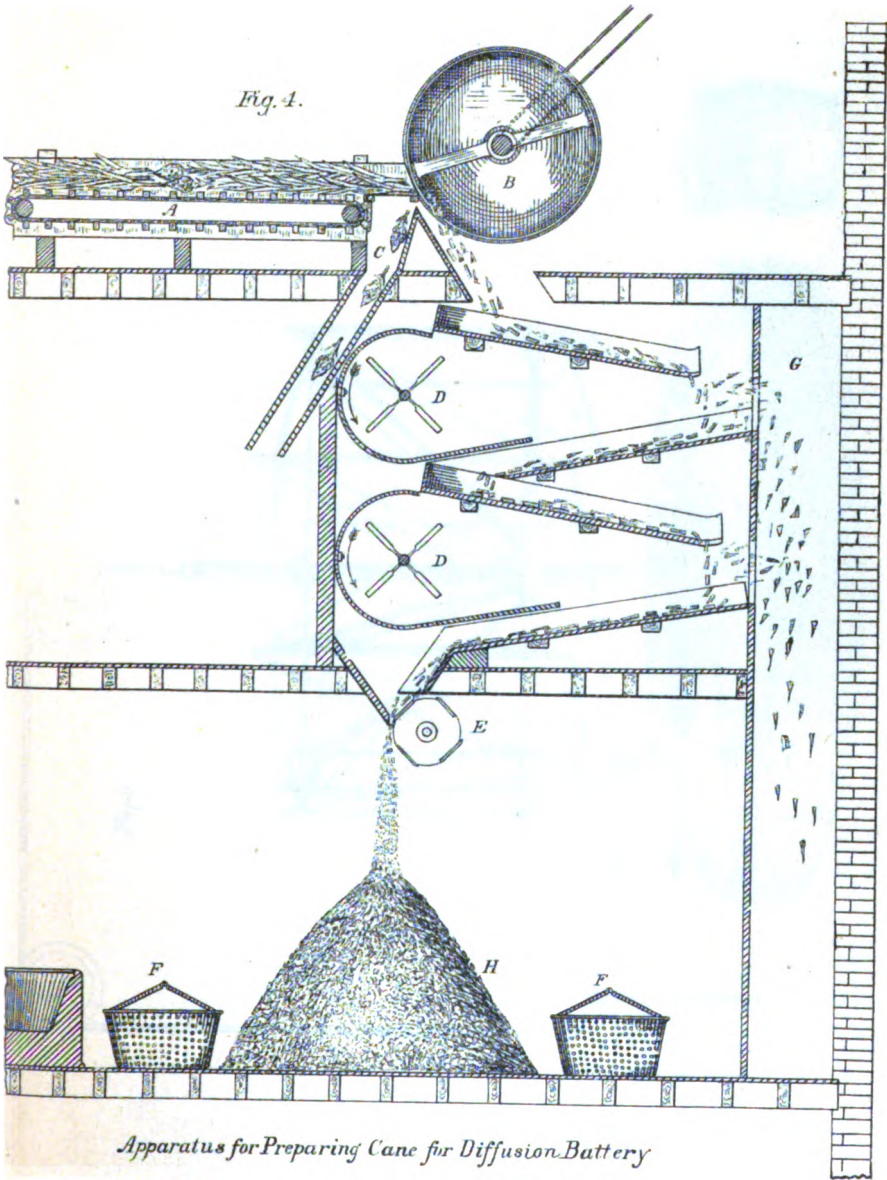
THE BATTERY.



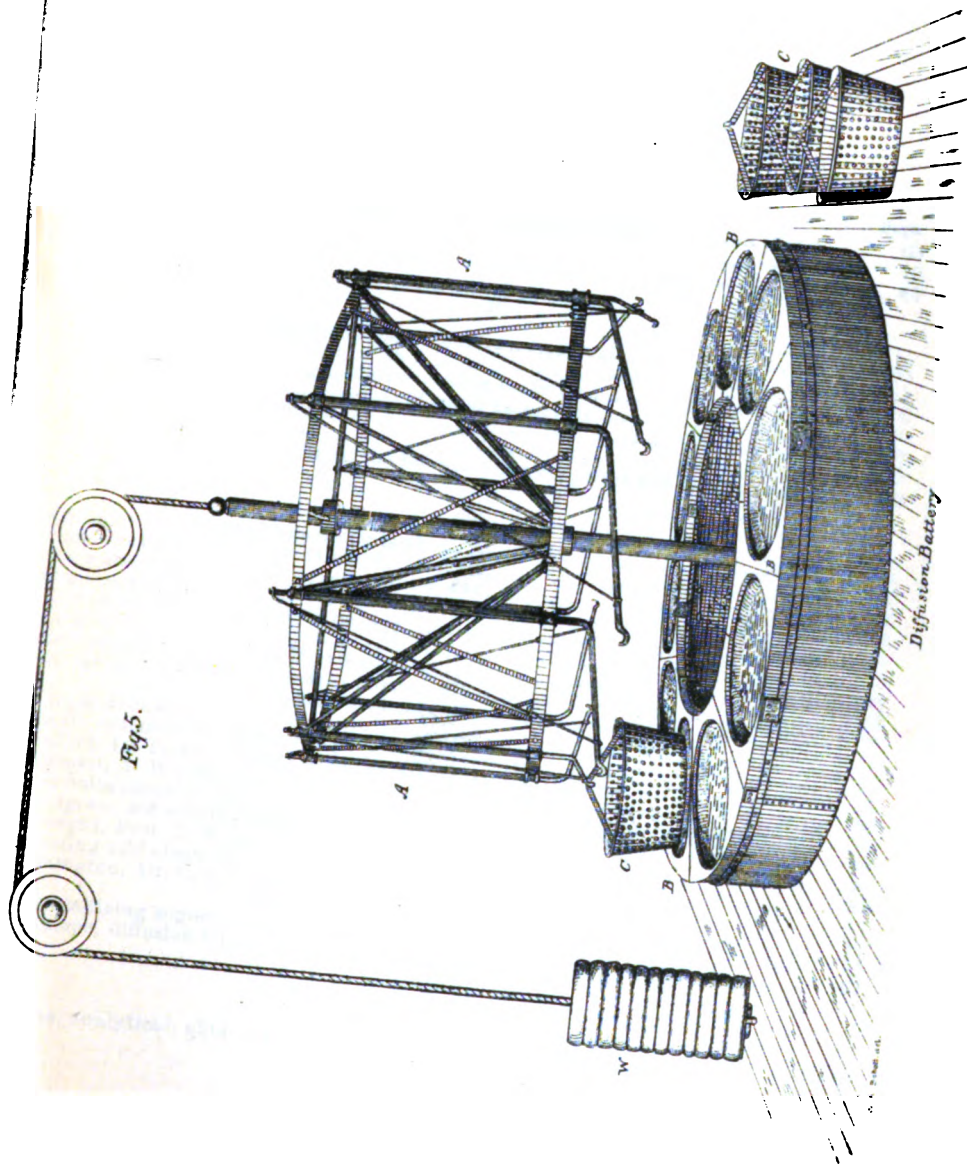
A. Brown & Co. Lith. New York.

DIRECTLY UNDER BATTERY.

Fig. 1.



Apparatus for Preparing Cane for Diffusion Battery



INDEX.

A.

	Page
Attorney-General, copy of statement of facts submitted to.....	63
Available sugar in sorghum	10
Analysis necessary in sugar factory.....	44

B.

Barthelemy, E. C., instructions sent to.....	77
Bauer's process, experiments with	111
Belle City Manufacturing Company, cutter made by.....	6
Bennyworth, Hon. John, erection of sugar factory by	21
Boiling to grain, description of	37
Bounty on sorghum sugar	19
Brown coal and wood char in the filtration of cane juices and sirups.....	98

C

Calumet sugar house, experiments at.....	99
Cane crushers, experiments with	7
Cane slicer built by Sangerhaiser Company.....	81
Cane sugar, inversion of	82
Carbonate of lime, use of, in battery	11
Central factories.....	55
Centrifugal machines at Fort Scott.....	39
Chemical work at Fort Scott, summary of	15
Rio Grande, summary of	71
Chips, disposition of.....	90
Coal consumed in diffusion experiments.....	94
Collier, Dr. Peter, studies on sorghum	21
Colwell, A. W., assistance rendered by.....	83
Commissioners of Agriculture, encouragement of sorghum by successive.....	26
Congress, aid solicited from	23
Cowgill, Prof. E. B., report of	21
Cutting and cleaning apparatus	41
Crampton, Dr. C. A., average analyses from tables prepared by	11
abstract of report of	15
Crystallizing sugars, experiments in.....	71
Cyclone, diffusion building injured by	62

D.

Data, analytical, obtained from first diffusion run.....	83
second diffusion run.....	84
third diffusion run	86
fourth diffusion run	87
fifth diffusion run	88
Defecation, experiments in	8
Densmore Bros., report of	56
Denton, A. A., report of	57
Department of Agriculture, early investigations by	21
further work of	22
Diffusion, description of the process of.....	34
battery, simplification of	40
first trial of.....	83

	Page.
Diffusion, second trial of.....	74
third trial of.....	85
fourth trial of.....	86
fifth trial of.....	87
trials, summary of results of.....	88
juices, characteristics of.....	89
experiments in Louisiana, description of.....	95
Double effect evaporators.....	96
Dugan, John, master of diffusion, experiments by.....	96
Dymond & McCall, Messrs., members of advisory committee.....	96

E.

Edson, Hubert, abstract of report of.....	71
Exhaust chips, utilization of.....	13
Experiments with diffusion at Lawrence, La.....	77

F.

Factory, cost of.....	12
Fake, N. J., chemical work by.....	96
Farmer's part most important in sugar making.....	32
Fehling's solution of copper.....	45
Field, J. A., & Co., mill made by.....	7
Filtering juices, experiments in.....	6
Filtration experiments, table of.....	100, 101, 103, 104
Fort Scott, experiments with sorghum at.....	5
company, organization of.....	24
factory, the work at.....	33

G.

Grape sugar test.....	45
-----------------------	----

H.

Heat, effects on sorghum juices.....	11
Hinze, Frederick, services at Fort Scott.....	37
Historical sketch of sorghum plant.....	21
Hughes, H. A., report of.....	67
cost of sugar factories estimated by.....	73

I.

Improving the seed.....	47
Ingalls, Hon. J. J., letter of transmission to.....	97
Inspector, Prof. E. B. Cowgill appointed as.....	18
Introductory letter.....	2
Inversion of sugar in the diffusion cells.....	35
in battery, prevention of.....	8

K.

Kleeman, F., experiments on lignite by.....	91
---	----

L.

Lawrence, La., experiments at.....	77
Louisiana sugar experiment station, native coals obtained from.....	102
Letters patent granted to M. Swenson.....	61
Liebold, S. A., & Co., erection of sorghum factory by.....	21
Lignite, report on, by W. J. Thompson.....	99
experiments with, by W. J. Thompson.....	91
F. Kleeman.....	91
use of, in Louisiana.....	91
experiments with, on sorghum.....	7

M.

Page.

Methods of analysis in sugar work	44
Mill and diffusion, comparative yield by	92

O.

Optical method of sugar analysis	46
Ottawa, Kans., report of work done at	23

P.

Parkinson, Hon. W. L., report of, to board of directors	26
Plumb, Senator, labors in behalf of an appropriation by	23

Q.

Quantity of juice drawn from each cell	93
--	----

R.

Remmers & Williamson, wood char process of	107
Rio Grande, N. J., experiments at	67
summary of chemical work at	71

S.

Sandys, R. M. & Co., erection of sorghum factory by	21
Sangerhauser Company, cutter built by	81
Maschinen-fabrik lignite imported from	100
Scientific work, need of, in sorghum factory	41
Scovell, Prof. M. A., factory of	22
Schulze, Ernest, assistance rendered by	82
Screens and sediment, disposition of	90
Season of working sugar, length of	51
at Rio Grande	60
Seed selection, improvement of sorghum by	48
Sieg, R., assistance rendered as consulting engineer	96
instructed to build cutter	82
Skimmings, disposition of, at Fort Scott	36
Silo, analysis of juice of cane, kept in	52
Frank Strobach's experiments in keeping cane in	51
storing cane in	51
Sims, William, secretary of State board of agriculture, instructions to Prof. E. B. Cowgill by	19
Sorghum, can the farmer make his own sugar from	56
available sugar in	10
cane, comparison of, with Louisiana cane	47
how far it may be hauled	56
crop of Rio Grande	68
industry, needs of	13
future of	50
in Kansas	18
seed, crop of	29
Spencer, G. L., experiments in filtration by, in 1886	107
in charge of lime-kiln and carbonatation apparatus	96
Stammer, Dr. Karl, text book of sugar making by	94
State of Kansas, encouragement of sorghum industry, by	25
Statement of facts submitted to the Attorney-General by the Commissioner of Agriculture	63
Sterling Sirup Works, experiments in air evaporation at	57
Strobach, Frank, experiments in keeping cane in silo, by	51
Sugar factories, capacity of	40
estimated cost of, by H. A. Hughes	73
making, outline of process of	31
Planters Association, reports of committee chosen by	78
refineries	60
Swenson, M., letters patent granted to	61
report of	5

Compliments of

Norman J. Colman,

Commissioner of Agriculture.

58
256
U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 18.

SUGAR-PRODUCING PLANTS.

RECORD OF ANALYSES

MADE BY AUTHORITY OF

THE COMMISSIONER OF AGRICULTURE,

UNDER DIRECTION OF

THE CHEMIST,

1887-'88.

SORGHUM:

FORT SCOTT, KANSAS; RIO GRANDE, NEW JERSEY.

SUGAR CANE:

LAWRENCE, LOUISIANA.

TOGETHER WITH A STUDY OF THE DATA COLLECTED
ON SORGHUM AND SUGAR CANE.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1888.

INTRODUCTORY LETTER.

SIR: I submit herewith, for your inspection and approval, Bulletin No. 18 of the Chemical Division.

In Bulletin No. 17 it is stated that much of the analytical work pertaining to the recent experiments in the manufacture of sugar was not ready for incorporation in that report. This work is now finished and tabulated and will be found in the following pages.

In view of the fact that the experiments which have been conducted for so long a time by the Department in the manufacture of sugar have come to a successful end, I have thought it would be useful here to collect together, in a condensed form, all the important recorded analyses of sorghum which I have been able to find. Where series of such analyses have been made, there are given only the means of the analyses, since to reproduce them singly would extend the size of the bulletin to undue proportions. For those, however, who may desire to study the analyses more minutely, references are given to original publications containing them. I have also added to this part of the work an abstract of recorded tonnage per acre for sorghum, yield of sugar per ton, and other data which may help to assist any one interested in the matter to an intelligent conclusion concerning the merits of sorghum as a sugar-producing plant.

In like manner I have epitomized the results of the analytical investigations which the Department has carried on for several years at Magnolia Plantation, Lawrence, La. Intending investors in establishments for manufacturing sugar should have access to a careful and unbiassed statement of the data on which the industry rests, and in the following pages an effort has been made to furnish this kind of information.

Reports written under the influence of prospective personal profit, or for pushing the claims of a patent, or to gratify personal pique or ambition, are likely to become the argument of the advocate rather than the charge of the non-partisan judge.

The persistent and often malicious misrepresentation of the work which has been done by the Department has not been without its baneful influence, although it has entirely failed of its chief purpose. The large number of persons interested in the culture of sugar beets, sorghum, and sugar cane recognize the value of the work which the

Department has done, a value which misrepresentation can not disparage nor selfish greed pervert.

In the work which has been done under my supervision I am not conscious of having withheld credit from others to whom it was due, nor of having claimed, for the Department, undeserved honor.

Exploring an unknown country, the real path of progress has often been lost to view, and for myself I am content if my labors have pointed out to others the road to success.

The cordial encouragement and support which I have received from you, even in the darkest hour of the work, have been most unqualified, and your faith in the ultimate success of the industry has never faltered.

The process of diffusion, by the efforts of your Department, has been fully established as the best and most economical method of extracting the sugar from the cane, and the way has been opened for private capital to extend and develop the sugar-producing power of our country until it shall be placed on a sure foundation of prosperity.

Respectfully,

H. W. WILEY,
Chemist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

ANALYTICAL WORK AT FORT SCOTT, SEASON OF 1887.

In the agreement made by the Commissioner of Agriculture with the Parkinson Sugar Company for conducting the experiments in the manufacture of sugar from sorghum during the season of 1887, provision was made for a complete chemical control of the work by the Chemical Division of this Department. Having been directed by the Commissioner of Agriculture to take charge of all the chemical work to be done at the three sugar stations, Dr. C. A. Crampton and Mr. N. J. Fake were directed to perform the analytical work at Fort Scott.

The following general directions were sent for conducting the work:

U. S. DEPARTMENT OF AGRICULTURE, CHEMICAL DIVISION,
Washington, D. C., August 29, 1887.

DEAR SIR: In conducting the analytical work at Fort Scott during the present season, you will be guided by the following general directions:

(1) Samples of cane from the wagon or cane-carrier are to be taken from time to time as last year, representing as nearly as possible the best, poorest, and medium canes which are brought to the factory.

(2) When the diffusion battery is in operation, a given weight of chips is to be taken from each of the cells until one complete round of the battery is represented.

These samples are to be preserved in a closed vessel until all are taken and then passed through a small mill and the expressed juice examined in the usual way.

(3) A measured sample of the juice discharged from each cell of the diffusion battery should be taken until one complete round has been made. These mixed samples of juice to be examined in the usual way.

(4) Samples of the juice above examined should be taken after the process of clarification, representing as nearly as possible the same body of juice as above, and examined in the usual way.

(5) After concentration to sirup, a sample should be taken, representing as nearly as possible the juice of the above two numbers and subjected to analysis.

(6) Samples of the *masse cuite*, sugar and molasses are to be taken, carefully labeled, and forwarded to the division here for examination.

(7) When the large mill is running, samples of the mixed juices should be taken as often as convenient and subjected to examination.

(8) The bagasse from the large mill should be examined from time to time, either by exhaustion with successive portions of water in an open vessel, or by exhaustion in a closed flask, a little freshly precipitated carbonate of lime being added to the water of maceration.

(9) Take from each cell of discharged chips a certain quantity representing as nearly as possible the mean character of the chips discharged from that cell after one complete circuit of the battery has been made, pass the samples so obtained through the small mill, and subject the expressed juices to examination.

Concerning the details of the analytical work, little need be said. Double polarization is not necessary except in cases where the canes may be badly injured, and you

will use your own discretion in this matter. You will please report by mail to this office at least once a week the general character of the analytical results obtained.

Any special chemical investigations desired by Mr. Parkinson or Mr. Swenson you will make, in so far as these may not interfere with the general work indicated above.

Respectfully,

H. W. WILEY,
Chemist.

Dr. C. A. CRAMPTON,
Fort Scott, Kans.

Later in the season additional instructions were sent to carefully compare the Brix spindles used in determining the total solids in the juice with the direct determination of solids by drying a weighed portion of the juice (2 grammes *circa*) and determining the per cent. water it contained. This was thought necessary because it was found that by determining the water directly in the *masse cuites* they were shown to have a higher co-efficient of purity than the juices from which they were derived.

The large mill which, it was expected, would be in operation, was not erected, and the directions to examine the juices therefrom were therefore superfluous.

The work at Fort Scott was begun on the 2d of September and ended October 19.

The sucrose in the juices was determined by polarization in a Laurent large model instrument, with white light attachment. During the later part of the season a Schmidt and Haensch double-compensating shadow instrument was employed to check the results of the instrument first named.

The glucose was determined by Fehling's (Violette's) solution.

The total solids were determined by Brix spindles and by direct weighing.

Following are the results of the analytical work :

ANALYSES OF JUICES OF SELECTED CANES.

For sampling different lots of cane, comparing saccharine richness, etc., the juice of single canes, or small collections thereof, was examined at different periods. In these cases it would be expected that much greater difference would be found than in the average samples of chips in the second table. The results show how rich single canes of sorghum may be in available sugar, and also how poor.

The maximum content of sugar is found in sample No. 9, viz, 14.20. The minimum is seen in sample No. 8, where the sucrose drops to 2.54 per cent.

DESCRIPTION OF SAMPLES.

- No. 1. Orange cane sample from Bullock.
2. Orange cane sample from Bowman.
3. Orange cane sample from Zoak.
4. Late planted early amber from Brown,

- No. 8. Honduras cane shipped by freight from Osage, Mich., to Fort Scott.
 20. Orange cane from wagons, average sample cut to dry.
 21. Amber cane from wagons, average sample cut to dry.
 28. Steward's hybrid cane.
 29. Honduras cane.
 31. Link's hybrid, from land of company west of railroad track.
 35. Link's hybrid, same field, east end.
 36. Link's hybrid, green from slough.
 37. Link's hybrid, brow of hill.
 38. Link's hybrid, brow of next hill.
 39. Mixture of orange and amber ripe cane.
 40. Amber cane from company's land.
 41. Link's hybrid, same field, green.
 42. Link's hybrid, same field, green.
 43. Link's hybrid, same field, green.
 148. Sample of cane cut and allowed to lie some time to show effect of inversion.
 253. Orange cane badly damaged by chinch bugs.
 254. Same, another sample.
 256. Orange cane from company's land.
 257. Orange cane from company's land.

TABLE NO. 1.—*Various analyses of mill juices from whole canes.*

Date.	No.	Brix (corrected).	Sucrose.	Glucose.
			<i>Per cent</i>	<i>Per cent.</i>
Sept. 2.....	1	16.63	11.30	.....
Sept. 2.....	2	19.13	13.20	.....
Sept. 2.....	3	19.65	13.11	.....
Sept. 2.....	4	19.13	12.17	.....
Sept. 5.....	8	18.43	2.54	.....
Sept. 9.....	20	15.87	7.83	5.43
Sept. 9.....	21	19.87	14.20	2.50
Sept. 10.....	28	17.87	11.03	3.43
Sept. 10.....	29	16.15	9.27	4.23
Sept. 10.....	31	18.37	12.44	2.23
Sept. 12.....	35	13.68	8.20	2.81
Sept. 12.....	36	14.68	9.03	2.46
Sept. 12.....	37	15.80	9.88	2.83
Sept. 12.....	38	17.30	12.21	1.75
Sept. 12.....	41	15.18	10.19	2.19
Sept. 12.....	42	12.43	5.95	2.78
Sept. 12.....	43	15.18	10.22	2.71
Sept. 12.....	39	16.28	10.85	4.01
Sept. 12.....	40	16.78	11.81	2.19
Sept. 24.....	148	19.31	3.32	9.36
Oct. 10.....	253	17.43	12.98	1.78
Oct. 10.....	254	17.93	13.67	.....
Oct. 10.....	256	12.99	7.75	.....
Oct. 10.....	257	15.31	9.80	.....
Means.....		16.72	10.12	3.35
Maxima.....		19.65	14.20	9.36
Minima.....		12.43	2.54	1.75

TABLE NO. 2.—*Mill juices from fresh chips.*

Date.	No.	Brix (corrected).	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>
Sept. 3.....	5	15.63	8.00	
Sept. 5.....	0	17.43	10.78	
Sept. 6.....	11	16.73	10.45	3.50
Sept. 8.....	16	16.68	10.34	
Sept. 9.....	23	15.87	6.20	0.49
Sept. 10.....	30	16.87	9.48	3.87
Sept. 10.....	33	14.70	8.50	4.10
Sept. 12.....	47	17.88	11.39	3.48
Sept. 13.....	51	17.06	9.50	3.84
Sept. 13.....	54	16.46	9.21	4.07
Sept. 15.....	69	17.00	10.08	3.62
Sept. 15.....	73	16.20	10.21	2.82
Sept. 16.....	81	15.93	10.15	2.96
Sept. 16.....	85	14.65	9.30	2.72
Sept. 17.....	88	17.47	9.99	4.09
Sept. 17.....	92	16.86	9.60	3.54
Sept. 19.....	96	16.07	10.40	2.67
Sept. 19.....	99	16.78	11.19	1.39
Sept. 20.....	106	16.80	10.21	3.05
Sept. 20.....	110	15.70	8.91	3.15
Sept. 21.....	123	17.68	9.48	4.20
Sept. 22.....	131	17.17	7.70	5.60
Sept. 22.....	134	17.73	7.07	5.34
Sept. 23.....	142	17.21	9.84	3.82
Sept. 23.....	146	16.70	10.24	
Sept. 24.....	149	19.00	9.80	3.31
Sept. 24.....	153	17.17	11.28	2.50
Sept. 26.....	161	16.51	8.80	3.93
Sept. 27.....	166	14.94	9.04	2.68
Oct. 1.....	174	16.79	10.39	3.10
Oct. 1.....	182	16.06	10.30	
Oct. 3.....	187	15.79	10.38	3.08
Oct. 3.....	193	15.69	10.38	2.68
Oct. 4.....	198	16.63	10.18	3.48
Oct. 4.....	203	15.83	9.88	2.88
Oct. 5.....	216	16.70	10.00	3.08
Oct. 5.....	222	16.58	10.20	3.67
Oct. 6.....	230	18.65	11.51	3.78
Oct. 7.....	238	16.10	9.60	3.53
Oct. 8.....	246	15.76	7.40	4.23
Oct. 11.....	258	15.21	9.59	3.15
Oct. 11.....	262	14.44	9.18	2.96
Oct. 12.....	265	14.73	9.13	3.44
Oct. 12.....	272	15.11	10.45	2.40
Oct. 13.....	278	14.97	9.22	3.17
Oct. 13.....	282	15.33	9.62	2.75
Oct. 14.....	287	15.69	9.54	3.53
Oct. 15.....	292	13.68	8.30	2.77
Oct. 15.....	295	14.24	9.02	2.69
Oct. 16.....	300	15.11	9.13	3.10
Oct. 17.....	304	15.31	8.85	3.39
Oct. 17.....	307	13.09	7.99	2.47
Oct. 18.....	311	15.81	9.47	3.03
Oct. 19.....	315	14.21	8.18	3.23
Oct. 19.....	318	14.93	8.46	3.60
Averages.....		16.14	9.54	3.40

A study of Table No. 2 reveals the same characteristics of sorghum juices which have been noticed in the work of previous years. The variations of the juice, however, from the mean have not been so pronounced as they were during the season of 1886, owing, doubtless, to the fact that the cane was, after harvesting, more promptly delivered to the factory and worked with less delay than during the previous season.

The maximum per cent. of sucrose was found in the juice obtained on October 6, viz, 11.51. Other notably good juices were secured on September 12, 19, and 24; the sucrose in these cases rising above 11 per cent. The minimum per centage of sucrose was found September 9,

viz, 6.20. Other notably poor juices are shown by the analyses of September 22 and October 17.

TABLE NO. 3.—*Diffusion juices.*

Date.	No.	Brix (corrected).	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>
Sept. 8.....	17	12.28	7.03	
Sept. 9.....	22	12.82	7.00	3.07
Sept. 10.....	34	12.32	6.51	2.90
Sept. 12.....	48	12.08	7.23	2.52
Sept. 13.....	52	12.28	7.19	2.78
Sept. 13.....	55	12.42	7.47	
Sept. 15.....	70	12.08	7.57	2.54
Sept. 15.....	74	12.62	8.30	2.30
Sept. 16.....	82	12.38	7.88	2.52
Sept. 16.....	86	13.10	8.79	2.33
Sept. 17.....	89	12.28	7.44	2.92
Sept. 17.....	93	12.28	7.82	2.63
Sept. 19.....	97	11.32	7.35	2.02
Sept. 19.....	100	12.28	8.00	1.94
Sept. 20.....	107	12.32	6.96	2.12
Sept. 20.....	111	12.32	7.51	2.30
Sept. 21.....	124	11.61	6.64	2.47
Sept. 23.....	132	10.85	5.80	2.94
Sept. 22.....	135	11.61	6.46	2.73
Sept. 23.....	143	11.47	6.71	2.76
Sept. 23.....	147	11.57	6.80	
Sept. 24.....	150	12.14	6.57	2.28
Sept. 24.....	154	10.95	6.92	1.93
Sept. 26.....	162	10.81	6.32	2.40
Sept. 27.....	167	10.17	6.37	2.02
Oct. 1.....	175	10.54	6.20	2.20
Oct. 1.....	183	10.12	6.25	
Oct. 3.....	189	10.24	6.15	2.08
Oct. 3.....	194	10.54	6.64	2.00
Oct. 4.....	199	10.51	6.27	2.01
Oct. 4.....	204	10.15	6.44	
Oct. 5.....	217	11.05	6.29	2.25
Oct. 5.....	223	11.68	7.15	2.41
Oct. 6.....	231	13.10	8.04	2.61
Oct. 7.....	239	10.98	6.54	2.09
Oct. 8.....	247	11.51	5.90	3.06
Oct. 11.....	259	10.39	6.58	2.09
Oct. 11.....	263	10.49	6.51	1.94
Oct. 12.....	266	9.97	6.17	2.03
Oct. 12.....	273	10.82	7.32	1.85
Oct. 13.....	270	9.71	5.97	1.89
Oct. 13.....	283	10.27	6.59	1.80
Oct. 14.....	288	10.17	6.02	1.80
Oct. 15.....	293	9.84	5.66	1.75
Oct. 15.....	290	10.24	6.58	1.98
Oct. 16.....	301	9.45	6.04	1.83
Oct. 17.....	305	8.74	5.05	2.06
Oct. 17.....	308	9.51	5.88	1.84
Oct. 18.....	312	9.67	5.66	2.02
Oct. 19.....	316	8.64	5.05	1.82
Oct. 19.....	319	8.77	5.05	2.05
Means.....		11.08	6.68	2.26
Maxima.....		13.10	8.79	3.07
Minima.....		8.74	5.05	1.80

The lowest sucrose in the diffusion juices was found on October 17 and 19, viz, 5.05 per cent., and October 17 and 18, viz, 5.88 and 5.66 per cent. This was at the close of the season. On only four preceding days did the percentage of sucrose fall below 6, viz, September 22, October 8, 13, and 15. The maximum per cent. of sucrose in the diffusion juice was found in sample No. 86, September 16, viz, 8.79.

The sample of mill juice corresponding to this number is found in Table No. 2, sample No. 85. The sucrose in this juice was 9.36 per cent.

Thus, while the content of sucrose in the chip juices for that day was 18 per cent. below the average for the season, the sucrose in the diffusion juice was 211 per cent. above it. These numbers show the difficulty of obtaining comparative samples in sorghum examinations. Single analyses are apt to be deceptive, and reliance should be placed rather on the work for the entire season.

TABLE NO. 4.—*Mill juices from exhausted chips.*

Date.	No.	Total sugars.	Date.	No.	Total sugars.
		<i>Per cent.</i>			<i>Per cent.</i>
Sept. 9....	24	.99	Oct. 1....	176	.57
Sept. 10....	32	1.19	Oct. 3....	189	.90
Sept. 12....	49	.56	Oct. 4....	200	1.01
Sept. 13....	56	.63	Oct. 5....	218	.88
Sept. 15....	71	.88	Oct. 6....	232	.84
Sept. 16....	84	1.09	Oct. 7....	240	.89
Sept. 17....	90	1.83	Oct. 8....	248	1.35
Sept. 19....	98a	.88	Oct. 11....	280	1.38
Sept. 19....	102	1.19	Oct. 12....	287	.91
Sept. 20....	108	1.14	Oct. 13....	280	1.43
Sept. 20....	112	.84	Oct. 14....	289	.76
Sept. 21....	125	1.22	Oct. 15....	294	1.02
Sept. 22....	133	1.27	Oct. 18....	313	1.42
Sept. 23....	145	.49			
Sept. 24....	151	.77	Average.....		1.03
Sept. 26....	163	.69			

The sucrose in the juice expressed from exhausted chips was inverted and estimated with the reducing sugar present, and the whole expressed as total sugars.

The ratio of the sucrose in the chips to the reducing sugar shows that the former is more readily diffused than the latter. This ratio was not determined for the whole season. From October 8 to 18, however, seven such analyses were made, with the following results:

TABLE NO. 5.—*Sucrose and glucose in juice from exhausted chips and corresponding diffusion juices.*

Date.	Exhausted chips.			Diffusion juices.		
	No.	Glucose.	Sucrose.	No.	Glucose.	Sucrose.
		<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Oct. 8....	248	.57	.78	247	3.06	5.90
Oct. 11....	260	.51	.87	259	2.09	6.58
Oct. 12....	267	.29	.63	266	2.03	6.17
Oct. 13....	280	.48	.95	279	1.89	5.97
Oct. 14....	289	.24	.52	280	1.80	6.02
Oct. 15....	294	.27	.75	293	1.75	5.66
Oct. 18....	313	.43	.99	312	2.02	5.66
Averages.....		.40	.78		2.09	5.99

Ratio of glucose to sucrose from exhausted chips 1 : 1.95
 Ratio of glucose to sucrose in diffusion juice 1 : 2.86
 Ratio of glucose to sucrose corresponding mill juice from fresh chips 1 : 2.69

The variations in the quantities of sugar left in the chips were due to differences in the quantity of diffusion juice drawn off at each charge, and to changes in rapidity of working. Rapid working with small quantities of juice drawn off leave more sugar in the chips than slower working and larger charges of diffusion juice.

Up to the 22d of September the quantity of juice drawn at each charge was 2,200 pounds. From this time to October 4, 2,640 pounds were drawn off each time. Thence to the close of the season 2,420 pounds. Assuming that each cell held 2,000 pounds of chips and the cane contained 90 per cent. juice, we have the following data :

Weight of chips in each cell.....	pounds..	2,000
Normal juice in each cell.....	do.....	1,800
Mean extraction (<i>circa</i>)	per cent..	93
Normal juice extracted from each cell.	pounds..	1,674
Charge withdrawn up to September 22	do.....	2,200
Weight added water	do.....	526
Percentage of dilution		32.02
Charge withdrawn September 22 to October 4.....	pounds..	2,640
Weight added water	do.....	966
Percentage of dilution		57.70
Charge withdrawn October 4 to close.....	pounds..	2,420
Weight added water	do.....	746
Percentage of dilution		44.56

With the modern appliances for evaporating sugar juices in multiple effect vacuum pans, the objections which have been urged against diffusion on account of the necessary dilution of the juice are of little force. A dilution of 60 per cent. is not at all incompatible with the complete economic success of the process.

TABLE NO. 6.—*Defecated juices.*

Date.	No.	Brix (corrected).	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>
Sept. 12...	53	13.35	8.25	2.66
Sept. 15...	72	13.02	8.23	2.55
Sept. 16...	87	13.28	8.87	2.23
Sept. 17...	91	12.48	7.90	2.53
Sept. 19...	98	10.90	6.99	1.88
Sept. 19...	101	12.58	8.09	1.97
Sept. 20...	109	12.84	7.93	2.11
Sept. 21...	126	12.05	7.39	-----
Sept. 22...	136	11.44	6.32	-----
Sept. 23...	144	11.24	6.50	2.35
Sept. 24...	152	10.58	6.43	2.08
Sept. 26...	164	10.81	6.11	2.38
Oct. 1...	184	10.14	6.28	-----
Oct. 3...	195	10.58	6.24	2.22
Oct. 4...	201	10.75	6.83	1.75
Oct. 5...	221	10.98	6.74	2.23
Oct. 6...	233	13.20	6.99	2.85
Oct. 7...	241	10.81	6.58	1.80
Oct. 8...	249	11.29	6.00	2.80
Oct. 11...	264	10.01	6.09	2.03
Oct. 12...	274	11.00	7.18	2.02
Oct. 13...	284	10.91	7.10	1.69
Oct. 15...	297	10.51	6.74	2.04
Oct. 17...	309	9.75	5.94	1.87
Oct. 19...	320	8.94	5.11	2.10
Averages		11.81	6.91	2.19

Dr. C. A. Crampton has furnished the following additional notes on the foregoing analytical work :

The first analysis of fresh chips was made on September 3, but the chemical control of the factory was not fully instituted until the 8th. This control consisted of

daily analyses of the fresh chips as supplied to the battery, of the diffusion juice, the defecated juice, and of the exhausted chips, together with analyses of the semi-sirup *masse cuite* and sugar from nearly every strike that was made. Great care was taken to have the analyses of the different products comparable with each other; the samples were always taken after at least one complete circuit of the battery had been made, as starting up the battery fresh did not allow of a proper extraction of the first cells filled. After the first round had been made a sample of the fresh chips was collected, an equal quantity being taken from each cell filled, the whole properly mixed and run through the small experimental mill, and the juice submitted to analysis. The sample of diffusion juice was taken from the same cells represented by the samples of fresh chips, by collecting and mixing together equal volumes from the drawings from each cell. The sample of exhausted chips was likewise collected from the same cells, and the juice obtained from them by pressure with the small mill. Thus the analyses of these three important products are strictly comparable and represent as truthfully as is possible, so far as the sampling is concerned, the character of the cane entering the battery, of the juice obtained from it, and of the waste matter thrown out. The defecated juices, having been boiled continuously in an open pan, samples could not be obtained which would correspond precisely with the samples of diffusion juice, but they were taken from a large receiving tank, which held the juice from a number of cells, so may be taken as a fair average of the defecated juice as it went to the double effect.

ANALYSIS OF WHOLE CANES, TABLE 1.

These analyses were made for various purposes and are inserted here simply as a matter of reference. They furnish additional proof, if any is needed, of the extreme variability of sorghum cane, and of the fact that analyses of a few selected canes give higher results than the average of a crop, and can not be depended on to show the average composition of a field of cane. Nos. 29-43 were taken from different parts of the same field, and at the same time. They show a content of sucrose all the way from 12.44 to 5.95 per cent. No. 148 shows very well the inversion sorghum undergoes by keeping after it is cut. It was taken from a load brought in by a farmer, and had doubtless lain in the field several days after it was cut. This analysis, which is simply an instance of what has been frequently observed before, shows the necessity for the rapid handling of sorghum after it is cut. It has been proposed to buy sorghum cane by its Brix indication, as is done with beets in some parts of Germany. This analysis, with a Brix indication of 19, and a polarization of 3.32, shows very conclusively that it would not pay very well to buy cane that had stood exposed on the degree Brix given by the juice.

TABLE NO. 7.—*Sirups (thick juices).*

Date.	No.	Brix (corrected).	Sucrose.	Glucose.
			<i>Per cent.</i>	<i>Per cent.</i>
Sept. 12.....	46	37.26	16.10	10.40
Sept. 13.....	57	41.60	25.75	7.90
Sept. 15.....	75	54.46	33.00	10.92
Sept. 17.....	94	41.80	28.70	7.69
Sept. 20.....	113	59.50	39.10	10.16
Sept. 22.....	128	-----	41.90	14.70
Sept. 23.....	137	46.80	29.90	9.62
Sept. 24.....	156	46.60	29.50	-----
Oct. 3.....	196	42.40	28.00	8.69
Oct. 6.....	234	60.40	35.10	16.26
Oct. 7.....	243	50.60	33.00	10.36
Oct. 12.....	268	36.20	24.20	6.42
Oct. 13.....	275	40.90	27.70	-----
Oct. 14.....	290	39.80	26.70	7.52
Averages.....		46.02	29.90	10.06

The variations in the proportion of sucrose to glucose in the thick juice as shown on Table No. 7 are much greater than would be expected from the analyses recorded in the foregoing tables. The thorough mixing of the products of large numbers of diffusion charges should tend theoretically to equalize the ratios of the two sugars. This remarkable variation is explained partly by the addition of sugar to the clarified juices in order to promote crystallization in the vacuum pan.

TABLE NO. 8.—*Masse cuites*.

No.	Moist- ure.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Not sugar.	Remarks.
	<i>Per cent.</i>	<i>Pr. ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Pr. ct.</i>	
5309	12.34	4.82	21.09	50.44	53.94	6.81	Not enriched.
5310	11.18	5.28	22.70	52.85	56.73	4.11	Do.
5311	11.47	4.22	15.92	62.40	66.47	1.92	Enriched.
5312	13.86	4.07	16.91	55.93	60.22	4.94	Do.
5313	13.58	4.13	15.02	60.52	65.30	1.37	Do.
5314	12.11	4.58	18.19	50.19	55.32	9.80	Not enriched.
5315	13.83	4.48	19.88	52.18	58.50	3.31	Do.
5316	12.74	4.81	16.83	60.24	64.01	1.62	Do.
5343	13.83	4.02	15.25	60.97	61.25	5.66	Enriched.
5381	16.72	5.09	19.60	57.64	55.83	2.75	Not enriched.
5385	17.80	4.73	21.00	50.28	51.76	4.72	Do.
5386	13.22	4.26	16.55	63.12	62.66	3.31	Enriched.
5387	14.48	4.48	15.83	63.16	62.63	2.58	Not enriched.
5388	13.59	4.83	16.40	57.84	59.64	5.24	Do.
5389	15.19	4.66	19.52	56.70	55.59	5.04	Do.
5344	14.38	4.50	17.36	61.79	61.83	1.93	Do.
5347	11.40	4.49	13.61	65.23	63.38	7.12	Do.
5348	12.96	5.01	15.20	61.79	61.51	5.82	Do.
5349	13.30	4.62	17.30	60.00	60.00	4.78	Do.
5353	12.55	7.14	17.78	59.10	59.62	2.91	Do.
5354	25.61	4.24	15.95	51.90	62.11	2.09	Do.
5355	15.59	4.93	18.18	54.03	58.91	2.39	Do.
5357	13.10	4.92	19.40	55.45	57.37	5.21	Do.
5358	22.01	4.80	16.68	54.86	52.18	4.33	Do.
5383	14.12	4.32	15.70	66.08	59.77	6.07	Do.
Ave ..	14.45	4.70	17.56	51.87	59.06	4.21	

The remarks applied to the analyses of the sirups, Table No. 7, belong equally well to Table No. 8. A distinction is made of the samples fortified by the addition of sugar. The differences between direct and double polarization, which are so plainly shown in the analysis of sirups, *masse cuites*, and molasses, will be discussed in another place. The greater reliance should be placed on the indirect polarization when it is carefully done. Yet the difficulties attending an accurate analysis of these substances are very great, and every precaution known to science will not always lead to perfectly satisfactory results.

The remarkable difference between the direct and indirect polarizations will at once be remarked in the mean results of Table No. 8. In general, as has been already said, the preference should be given to the indirect polarization when carefully done. In the present case, however, the percentage of sucrose by indirect polarization appears to be too high. The mean percentage of organic solids not sugar is only 4.21, a much less proportion than would be expected.

TABLE NO. 9.—*Polarization of first sugars.*

No.	Sucrose.	No.	Sucrose.
	<i>Per cent.</i>		<i>Per cent.</i>
6	97.90	202	96.60
60	95.00	224	95.29
61	96.70	229	96.40
77	94.10	236	94.80
104	97.80	245	93.80
105	91.20	250	94.90
129	96.50	251	94.20
139	94.20	277	95.30
159	97.30	281	96.10
160	97.60	286	93.70
165	97.20	302	92.40
168	96.30	303	95.60
169	97.10	310	93.60
192	96.70		
	Mean ..		95.64

TABLE NO. 10.—*Second sugars.*

No.	Sucrose.
	<i>Per cent.</i>
83	82.30
173	88.70
255	86.40
Mean ..	85.80

The first sugars, as shown by Table No. 9, had a mean content of sucrose equal to 95.64 per cent. The color of these sugars was mostly grayish yellow, and most of the samples could be used for the coarser kinds of table use and for cooking without refining.

Only a small quantity of second sugars was made, it having proved more profitable to sell the molasses than to work it into sugar.

The composition of the second sugars is sufficiently indicated by Table No. 10.

TABLE NO. 11.—*Molasses from first sugars.*

Station No.	Serial No.	Molsture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Not sugar.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
261	82	16.42	6.59	28.10	36.67	35.66	13.31
59	5318	25.25	6.18	27.96	37.55	37.60	3.01
79	5320	23.49	5.97	23.76	34.52	35.60	11.18
89	5521	25.56	5.91	23.15	35.16	35.30	10.08
97a	5322	28.04	5.22	22.73	38.67	38.90	5.11
103	5323	23.36	6.44	27.47	37.39	37.00	5.73
130	5324	23.01	6.04	24.32	35.16	36.20	10.43
140	5325	22.22	7.12	25.00	31.32	31.70	13.96
Averages		23.42	6.17	25.31	35.81	36.00	9.10

In Table No. 11 is given the composition of the molasses after separating the first sugar. The increase in per cent. sucrose on double polarization is not as great as the results with *masse cuites* would lead us to expect.

The samples taken from the tanks at different times represent fairly well the average composition of the whole for the entire season.

The sucrose remaining after the first crystallization is seen to be nearly 1.5 times the reducing sugar.

The composition of the molasses gives a check on the yield of sugar per ton, which the failure to weigh the cane left to a certain extent undetermined. Supposing that there was no appreciable destruction of reducing sugar during the process of clarification, and no inversion of sucrose during the evaporation, the relative composition of the molasses and diffusion juices will indicate the theoretical yield in sucrose. Since, however, the quantity of diffusion juice drawn off is difficult to determine from the data furnished, the comparison will have to be made on the composition of the normal juice expressed from the samples of fresh chips.

In these juices the mean composition for the season was—

	Per cent.
Sucrose	9.54
Reducing sugars	3.40

In the molasses the proportion of reducing sugars to sucrose is—

25.31 : 36.00, or 1.42.

Now, the product of 3.40 by 1.42 is 4.83; and $9.54 - 4.83 = 4.71$, the percentage of sucrose obtained in first sugars.

In 1 ton of cane chips there are, in round numbers, 1,800 pounds juice. The extraction was 93 per cent., or 1,674 pounds. The theoretical quantity of pure sucrose obtained per ton was, therefore, 78.8 pounds.

The mean polarization of the first sugars was 95.64. Then $78.8 \div 95.64 = 82.38$ = number of pounds actual weight first sugar produced per ton.

The yield per ton is estimated at 100 pounds by Mr. Swenson¹. By Mr. Cowgill the yield per ton is estimated at 93.8 pounds per ton². A fact worthy of remark will be noticed on comparing this yield with the output at Rio Grande and Magnolia, to be mentioned further on. It is this: That the quantity of sugar obtained at the first crystallization can not be determined by any fixed rule based on the relative proportions of sucrose and glucose in the juice. As the proportion of sucrose diminishes the relative amount obtained rapidly increases. At Rio Grande, for instance, the quantity of sucrose remaining in the molasses after the first crystallization is actually less in some cases than the glucose. In Louisiana, even after a second or third crystallization, more sucrose than glucose will usually—not always—be found in the molasses.

In the working of sorghum of the richness indicated by the foregoing analyses, it is a grave question whether a second crystallization is commercially desirable or even practicable. The difficulty of drying the second *masse cuite* in the centrifugals is often so great as to render it commercially unprofitable. Until the quality of sorghum, therefore, is

¹ Bull. 17, p. 10.

² Ibid, p. 49.

improved it will be well to base all calculations on the yield of first sugars alone. This yield, with such cane as mentioned, will be 4 to 4.5 per cent. on the weight of clean cane.

TABLE NO. 12.—*Second masse cuite.*

No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Not sugar (organic).
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5345	19.34	7.08	27.30	39.15	38.65	7.63
5354	18.02	6.93	29.70	39.68	44.61	1.04
5356	21.00	7.26	26.45	40.52	41.98	3.31
Means	19.45	7.09	27.82	39.78	41.84	3.99

TABLE NO. 13.—*Molasses from seconds.*

No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Not sugar (organic).
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5350	25.62	8.06	31.35	32.40	29.08	5.89
5351	24.42	8.00	30.85	35.60	33.58	3.15
5380	26.14	7.53	29.78	31.66	30.68	5.90
Means	25.39	7.86	30.66	33.22	31.11	4.98

In the second *masse cuites* the only marked difference from the first molasses is in the degree of evaporation.

In the second molasses we see the sucrose about in the same proportion as the glucose. It is also less by double polarization—a fact difficult of explanation.

TOTAL SOLIDS IN JUICES.

In Tables Nos. 1, 2, and 3 the total solids represent the readings of the hydrometer graduated to give the quantity of pure sugar in an aqueous solution, and corrected for temperature.

It is evident that in a cane juice containing large quantities of solids other than pure sucrose, these readings can give only approximately the percentage of dry solid matter in solution.

Instructions were therefore sent to Fort Scott to determine dry volatile matter or total solids by evaporating a weighed portion of the juice and noting the weight of the residue dried to practically constant weight at 105° C. This operation was carried on in a flat platinum dish, about 2 grams of the juice being used in each case. The results showed a marked difference in the data furnished by the Brix hydrometer and the direct method, the latter being uniformly lower, thus increasing the apparent purity of the juice. In this operation, however, the difficulty of securing uniform desiccation is great. The greater the quantity of solid matter contained in a given juice the more difficult is it to secure the complete removal of the water. The

differences noted, therefore, in the case of the mill juices are greater than in the juices of diffusion. This matter will be referred to again in the Louisiana analyses to follow. In Table No. 14 the differences are given:

TABLE NO. 14.—*Comparison of total solids by spindle with results obtained by direct estimation.*

Mill juices.			Diffusion juices.		
No.	Direct.	Indirect.	No.	Direct.	Indirect.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
238	15.67	16.10	239	10.15	10.98
246	14.95	15.76	247	10.51	11.51
258	14.55	15.21	250	9.50	10.39
262	13.85	14.44	263	9.60	10.40
265	14.40	14.73	266	9.00	9.97
272	14.80	15.11	273	10.05	10.82
278	14.40	14.97	279	8.85	9.71
282	14.85	15.33	283	9.40	10.27
292	13.40	13.68	293	8.43	9.34
295	13.60	14.24	296	9.30	10.24
300	14.78	15.11	301	8.58	9.45
304	14.85	15.31	305	8.10	8.74
307	12.50	13.09	308	8.80	9.51
313	13.65	14.21	312	8.75	9.67
318	14.65	14.93	316	7.10	8.64
			319	8.05	8.77
Aver	14.33	14.81	Aver	9.06	9.91

Dr. Crampton makes the following observations on this work:

These results are very interesting and important. They show that while the spindles give results but slightly below the actual determination by drying in the case of mill juices, the results with the diffusion juices were, on an average, .85 too high. The spindles used were tested afterwards with a standard solution of pure sugar, and found to give results about .2 too high. They corresponded closely with a delicate saccharimeter tested by Scheibler. The different results given by them in the case of the mill and diffusion juices I am unable to explain, as it would seem more rational that the diffusion juices, being more nearly pure solutions of sugar than the mill, would give results approximating more closely to the standard upon which the spindles were based. It is possible that the large amount of suspended solids in the mill juices may in some way account for the discrepancy. At all events the direct determination doubtless gives more reliable results. Correcting the average results on the basis of the samples in which a direct estimation was made we have:

Total solids in the mill juices for the season	15.66
Co-efficient of purity based on above	60.9
Total solids in diffusion juices for the season	10.23
Co-efficient of purity	65.3

Showing an increase in the purity of the diffusion over the mill juices of 4.4 points. The ratio of glucose to sucrose in the two juices for the season was as follows:

Mill juice	1 : 2.80
Diffusion juice	1 : 2.95

This would seem to show one of two things: Either there was absolutely no inversion in the battery, and the slight difference in favor of the diffusion juice was due to error of analysis, or that the glucose in the cane was not so readily diffusible as the sucrose, and thus a greater proportionate amount of the latter was obtained by diffusion

than by milling, sufficient to cover whatever slight inversion there was in the battery, and leave a margin beside. The latter hypothesis seems to be borne out by the analysis of the exhausted chips. Up to October 8 the total sugar remaining in the chips was determined, no separate analyses being made of glucose and sucrose. After that date both sugars were estimated. Table No. 5 gives the results, together with the sucrose and glucose in the corresponding diffusion juices:

TABLE NO. 15.—*Acidity in mill juices and diffusion.*

Mill juice.		Diffusion.	
No.	C. C. ⁿ ₁₀ alk. for 100.	No.	C. C. ⁿ ₁₀ alk. for 100.
174	32.0	175	14.4
193	28.8	194	16.8
198	38.0	199	20.0
222	32.0	223	18.4
230	39.0	231	22.8
236	32.4	230	26.0
246	36.0	247	20.0
258	10.0	259	16.0
265	26.0	266	15.2
278	34.0	279	18.0
292	18.0	293	10.0
304	34.0	305	12.0
311	21.0	312	8.0
315	26.0	316	10.0
Mean.	29.1	Mean.	16.3

The work recorded in Table No. 15 was undertaken to show the extent to which the carbonate of lime added to the diffusion cells neutralized the free acids of the juice. The numbers indicate the quantity of tenth normal alkali required to neutralize the acids in 100 cubic centimeters of the juice. Taking as a basis of comparison the total solids in the mill and diffusion juices for the season, as indicated in Tables Nos. 2 and 3, the following data are obtained:

Total solids in mill juices.....	16.14
Total solids in diffusion juices.....	11.08
Acidity of mill juice.....	29.1 cc.

The normal acidity of the diffusion juice, had no carbonate been used, is obtained by the following calculation:

$$16.14 : 11.08 = 29.1 : X; \text{ whence} \\ X = 19.98$$

The mean quantity of alkali required for neutralizing the acid in the diffusion juice was 16.3 cubic centimeters. Deduct this number from the calculated normal number and the difference, viz, 3.68 cubic centimeters, represents the amount of acid neutralized.

The percentage of acid neutralized is therefore $3.68 \div 29.1 \times 100 = 12.65$. The action of the carbonate, therefore, in neutralizing the acids is not as far reaching as the experiments made by the Department and recorded in Bulletin 14 would lead us to expect.

Dr. Crampton has made the following report respecting the extraction of sugar :

The mill juice from exhausted chips contained 1.03 per cent. of total sugars. This gives the total sugars as 92.04 per cent. of the amount contained in the cane. Supposing the ratio of glucose to sucrose in the exhausted chips for the whole season to have been the same as that shown during the time that the two sugars were estimated separately, the average sucrose remaining would be .68 per cent. in the juice, or .61 per cent. of the chips themselves. This would give an extraction of 92.87 per cent. of the total sucrose present in the cane.

This is not so good an extraction as has been obtained in previous experiments with diffusion on cane. It is explained by Professor Swenson on the ground that the chips were not made fine enough, gaps in the knives of the small cutters, made by stones, etc., getting into it, allowing of the passage of comparatively large pieces of cane.

WORK AT RIO GRANDE, N. J.

The general instructions sent to the Fort Scott station were given also to the analysts at Rio Grande, with such changes only as the locality required.

Mr. F. V. Broadbent was placed in charge of the analytical work, with Mr. Hubert Edson as assistant. Mr. Broadbent resigned his position early in October. Mr. Edson then took charge of the work and remained until the close of the season. With the assistance of one boy he successfully conducted the chemical control of the factory.

In the following tables are given the results of his work:

TABLE NO. 16.—*Juices from diffusion chips.*

Date.	Specific gravity.	Baumé.	Brix (corrected).	Sucrose.	Purity.	Glucose.
				<i>Per cent.</i>		<i>Per cent.</i>
Sept. 8	1.057	7.6	14.06	7.94	56.47	
Sept. 9	1.059	8.1	13.96	8.88	63.61	
Sept. 10	1.057	7.7	13.53	8.34	61.64	
Sept. 12	1.052	7.2	12.82	7.95	62.10	
Sept. 13	1.052	7.2	12.80	8.10	63.28	
Sept. 15	1.051	7.1	12.90	7.37	56.87	3.46
Sept. 17	1.054	7.5	12.83	8.01	62.43	3.22
Sept. 19	1.050	6.9	12.26	7.29	59.46	3.79
Sept. 19	1.052	7.2	22.92	7.33	58.73	4.07
Sept. 20	1.055	7.6	12.96	7.61	58.72	3.13
Sept. 20	1.057	7.8	13.62	7.52	55.21	3.39
Sept. 21	1.060	8.4	16.47	11.63	70.61	2.52
Sept. 21	1.072	9.8	17.80	12.28	68.99	2.76
Sept. 22	1.063	8.6	15.28	10.88	71.20	2.46
Sept. 23	1.059	8.1	13.90	8.32	59.86	3.04
Sept. 24	1.058	7.8	13.86	8.55	61.69	3.45
Sept. 26	1.061	8.3	14.23	9.09	63.88	2.97
Sept. 27	1.058	7.9	13.71	8.42	61.42	3.63
Sept. 27	1.061	8.3	14.37	8.99	62.56	3.86
Sept. 28	1.060	8.0	14.20	8.80	61.97	3.32
Sept. 29	1.053	7.3	13.02	8.29	63.67	3.30
Oct. 1	1.053	7.3	13.01	7.98	61.34	3.05
Oct. 3	1.055	7.6	14.19	9.25	65.19	3.15
Oct. 3	1.056	7.7	13.74	8.43	61.36	3.99
Oct. 4	1.060	8.2	14.67	8.83	60.19	3.53
Oct. 4	1.058	7.9	14.31	9.34	65.27	3.59
Oct. 5	1.057	7.8	13.80	9.21	66.74	2.70
Oct. 6	1.059	8.1	15.03	9.19	61.14	3.36
Oct. 7	1.057	7.8	13.88	8.94	64.41	3.68
Oct. 8	1.056	7.7	13.66	7.40	61.49	3.71
Oct. 9	1.065	8.9	15.94	10.95	68.70	2.87
Oct. 10	1.065	8.9	16.33	11.64	71.28	3.01
Oct. 11	1.066	9.0	15.61	11.02	70.42	3.05
Oct. 11	1.067	9.1	15.78	10.80	68.44	3.12
Oct. 13	1.056	7.9	13.40	9.08	60.47	2.94
Oct. 13	1.060	8.2	14.58	9.27	63.58	3.29
Oct. 14	1.059	8.1	14.34	9.34	65.13	3.18
Oct. 14	1.057	7.8	13.86	9.61	69.34	
Oct. 15	1.058	7.9	13.77	8.72	63.33	3.51
Oct. 17	1.070	9.5	16.71	11.40	68.22	3.13
Oct. 17	1.070	9.5	16.86	11.51	68.27	
Oct. 18	1.069	9.4	16.73	11.47	68.56	3.28
Oct. 19	1.066	8.2	14.30	9.36	65.45	3.06

TABLE NO. 16.—*Juices from diffusion chips*—Continued.

Date.	Specific gravity.	Baumé.	Brix (corrected.)	Sucrose.	Purity.	Glucose.
				<i>Per cent.</i>		<i>Per cent.</i>
Oct. 20	1.056	7.7	13.26	8.49	64.02	2.83
Oct. 20	1.056	7.7	13.28	8.52	64.14	2.83
Oct. 21	1.050	6.9	11.90	7.29	61.26	2.56
Oct. 21	1.053	7.3	12.53	7.79	62.17	2.94
Oct. 23	1.048	6.7	11.24	6.81	60.59	2.99
Oct. 24	1.065	8.9	15.21	10.42	68.51	2.07
Oct. 24	1.065	8.9	15.47	10.39	67.16	.....
Oct. 25	1.051	7.1	12.26	6.74	54.97	3.74
Oct. 26	1.045	6.1	10.45	4.71	45.07	4.45
Oct. 27	1.056	7.7	13.43	8.85	65.90	3.49
Oct. 27	1.059	8.1	14.10	9.20	65.25	3.73
Oct. 29	1.052	7.2	12.57	8.12	64.60	3.40
Oct. 31	1.053	7.3	12.24	8.16	66.66	3.78
Oct. 31	1.056	7.7	13.05	7.70	59.00	3.55
Nov. 1	1.062	8.5	14.52	9.95	68.52	3.30
Nov. 2	1.062	8.5	14.35	9.96	69.47	3.88
Nov. 3	1.062	8.5	14.74	10.08	68.38	.....
Nov. 8	1.061	8.3	14.20	9.48	66.29	3.53
Means ..	1.067	7.8	14.02	8.98	64.05	3.24
Maxima ..	1.070	9.5	17.80	12.28	71.28	4.45
Minima ..	1.045	6.3	10.45	4.71	45.07	2.07

The analyses of the samples of chips taken from each charge of the battery, often twice daily, show the remarkable fluctuations in sucrose which have always been noticed in sorghum juices.

The mean composition of the normal juice, Table 16, shows a less percentage of sucrose, but a somewhat higher purity than were obtained at Fort Scott.

The maximum percentage of sugar in the juice is not as great as at Fort Scott, and the minimum is not so small. In general it may be said that the canes worked at Rio Grande were slightly inferior for production of sugar to those of Fort Scott.

The theoretical yield per ton, based on the Fort Scott analyses, would have been as follows:

Pounds of juice at 93 per cent. extraction	1,674.
Glucose x 1.42	4.60
Sucrose less glucose x 1.42	4.38
Pure sucrose, first crystallization	73.32
Pure sucrose, etc., at Fort Scott	78.8

The yield obtained, for various reasons, was much less than this.

The tonnage obtained at Rio Grande, however, was fully double that at Fort Scott, and this heavy growth may account for the slightly inferior quality of the cane.

TABLE NO. 17.—*Diffusion juice.*

Date.	Specific gravity.	Baumé.	Brix.	Brix (corrected).	Sucrose.	Purity.	Glucose.
1887.		°	°		Per cent.		Per cent.
Sept. 8.....	1.040	5.6	9.0	9.57	5.69	59.46	.....
Sept. 9.....	1.040	5.6	9.1	10.21	6.21	60.82	.....
Sept. 10.....	1.040	5.6	9.1	9.92	5.57	56.15	.....
Sept. 12.....	1.033	4.7	8.1	8.91	5.58	62.63	.....
Sept. 13.....	1.037	5.2	9.0	9.61	6.03	62.75	.....
Sept. 15.....	1.037	5.2	9.2	9.77	5.43	55.58	.....
Sept. 17.....	1.045	6.3	10.4	10.43	6.71	64.83	2.83
Sept. 19.....	1.040	5.6	9.6	10.16	5.74	56.50	2.85
Sept. 20.....	1.045	6.3	10.5	10.95	6.18	56.44	3.27
Sept. 20.....	1.047	6.5	11.1	11.55	6.68	57.84	.....
Sept. 21.....	1.050	6.9	11.8	12.18	8.47	69.54	2.12
Sept. 21.....	1.060	6.9	12.8	13.22	8.97	67.85	2.17
Sept. 22.....	1.060	8.2	14.0	14.40	9.90	68.75	2.72
Sept. 23.....	1.055	7.6	12.8	13.06	7.51	57.50	3.00
Sept. 24.....	1.051	7.1	12.3	12.30	7.07	57.47	3.24
Sept. 26.....	1.042	5.9	9.5	9.56	6.18	64.64	2.09
Sept. 27.....	1.052	7.2	12.4	12.60	7.72	61.27	3.27
Sept. 27.....	1.055	7.6	12.5	12.80	7.81	61.02	3.51
Sept. 28.....	1.053	7.3	12.5	12.77	7.47	58.58	8.27
Sept. 29.....	1.051	7.1	11.6	12.33	7.81	63.34	3.16
Oct. 1.....	1.046	6.4	10.0	11.58	7.09	61.20	3.09
Oct. 3.....	1.040	5.6	10.0	11.12	6.86	61.69	2.37
Oct. 3.....	1.052	7.2	12.1	12.62	7.55	59.83	3.66
Oct. 4.....	1.044	6.1	10.2	10.80	6.73	61.74	3.19
Oct. 4.....	1.066	7.1	12.8	13.39	8.70	64.97	3.82
Oct. 5.....	1.043	6.0	10.1	10.35	6.62	63.96	2.50
Oct. 6.....	1.045	6.3	10.6	11.01	6.98	63.40	2.62
Oct. 7.....	1.038	5.3	8.9	9.28	5.89	63.43	2.53
Oct. 8.....	1.035	4.9	7.9	8.44	5.08	60.19	2.03
Oct. 10.....	1.042	5.9	10.4	10.87	7.42	68.26	2.19
Oct. 10.....	1.058	7.9	13.6	14.30	10.02	70.07	3.10
Oct. 11.....	1.057	7.8	13.5	13.73	9.58	69.78	2.94
Oct. 11.....	1.052	7.2	12.1	12.58	8.49	67.49	2.18
Oct. 13.....	1.045	6.3	10.5	10.62	6.85	60.47	2.50
Oct. 13.....	1.052	7.2	12.3	12.66	8.28	65.40	2.94
Oct. 14.....	1.051	7.1	12.2	12.58	8.11	64.47	2.91
Oct. 14.....	1.053	7.3	12.3	12.85	8.66	67.39	3.01
Oct. 15.....	1.047	6.5	10.9	10.88	7.14	65.02	2.81
Oct. 17.....	1.034	4.8	7.9	8.42	6.19	71.14	1.57
Oct. 17.....	1.045	4.9	8.2	8.82	6.24	70.75	.....
Oct. 18.....	1.035	4.9	8.2	8.60	6.01	69.77	1.91
Oct. 19.....	1.036	5.1	8.5	8.82	5.78	65.53	2.13
Oct. 20.....	1.047	6.5	10.8	11.18	7.09	63.42	2.69
Oct. 20.....	1.046	6.4	10.8	11.31	6.97	61.64	2.57
Oct. 21.....	1.039	5.5	9.1	9.51	5.54	54.05	2.46
Oct. 21.....	1.045	6.3	10.4	10.73	6.52	60.76	2.53
Oct. 22.....	1.041	5.7	9.5	9.77	5.70	56.19	2.80
Oct. 24.....	1.035	4.9	8.0	8.40	5.81	69.17	1.32
Oct. 24.....	1.048	6.7	11.4	11.91	5.77	48.78	.....
Oct. 25.....	1.046	6.4	10.9	11.35	5.92	52.16	3.33
Oct. 26.....	1.037	5.2	8.5	8.78	3.89	44.31	3.97
Oct. 27.....	1.050	6.9	11.8	12.08	7.61	63.00	3.54
Oct. 27.....	1.055	7.6	12.7	13.00	7.97	61.31	3.60
Oct. 29.....	1.043	6.0	10.0	10.37	6.49	62.58	3.10
Oct. 31.....	1.036	5.1	8.2	8.38	5.05	60.26	2.75
Oct. 31.....	1.045	6.3	10.6	11.04	6.23	56.43	3.45
Nov. 1.....	1.050	6.9	11.7	11.82	6.72	56.93	3.68
Nov. 2.....	1.059	8.1	13.4	13.40	8.73	65.15	3.88
Nov. 3.....	1.056	7.7	13.1	13.53	8.63	63.69	.....
Nov. 8.....	1.056	7.7	13.2	13.26	8.41	63.71	3.74
Means....	1.046	6.4	10.6	11.18	6.93	61.98	2.56
Maxima..	1.060	8.2	14.0	14.40	10.02	71.14	3.97
Minima..	1.033	4.7	7.9	8.38	3.89	44.31	1.32

The system of diffusion employed at Rio Grande is fully explained by Fig. 5, Bulletin No. 17. It differs radically from the system of closed diffusion. As operated at Rio Grande last year the extraction was no better than by good milling in Louisiana, while the dilution was fully as great as at Fort Scott and Magnolia.

The defects of the system were both mechanical and chemical.

The mechanical difficulty is the same as that which attends all methods of diffusion in which the cane chips are moved instead of the diffusion liquors. From a mechanical point of view, it is far easier and more economical to move a liquid in a series of vessels than a mass of chips. In the Hughes system the whole mass of chips undergoing diffusion, together with adhering liquor, and baskets and suspending apparatus, are lifted vertically a distance of several feet, varying with the depth of the diffusion tanks every few minutes. The mechanical energy required to do this work is enormous, and with large batteries the process would prove almost impossible.

The chemical defects of the system are shown in the exposure of so large a surface to oxidation and the action of invertive ferments. It is not surprising, therefore, to notice a distinct increase in the ratio of glucose to sucrose in the data of Table No. 17. Diffusion in open vessels was tried years ago with the sugar beet, and was abandoned as being both unscientific and expensive. The degree of extraction in open vessels is also less perfect than in closed diffusers where a considerable pressure is exerted on the osmotic liquors. It is but just to say, however, that the poor extraction obtained at Rio Grande is due more to the low temperature at which the diffusion took place than to the open diffusion vessels. I measured the temperature several times at the beginning of the season and found it below 60° C.

By certain modifications made after the close of the season, Mr. Hughes obtained a better extraction. (Bulletin 17, p. 67.)

The composition of the diffusion juices is sufficiently shown in Table No. 17.

TABLE NO. 18.—*Exhausted chip juice.*

Date.	Specific gravity.	Baumé.	Brix.	Brix (corrected.)	Sucrose.	Purity.	Glucose.
		°	°	°	Per cent.		Per cent.
Sept. 8..	1.019	2.7	4.5	5.05	3.22	63.76	.....
Sept. 9..	1.012	1.7	2.2	2.55	1.82	71.37	.....
Sept. 10..	1.018	2.6	3.9	4.59	3.07	66.88	.....
Sept. 12..	1.017	2.4	3.8	4.42	2.58	62.67	.....
Sept. 13..	1.016	2.3	3.7	4.22	2.67	63.27	.....
Sept. 15..	1.019	2.7	4.0	4.55	2.62	57.60	.....
Sept. 17..	1.016	2.3	3.1	3.12	2.03	65.01	.97
Sept. 19..	1.011	1.6	2.0	2.70	1.73	64.07	.73
Sept. 20..	1.007	1.0	1.2	1.70	.99	58.23	.50
Sept. 20..	1.010	1.4	1.9	2.30	1.16	50.43	.54
Sept. 21..	1.007	1.0	1.3	1.68	.98	58.33	.35
Sept. 21..	1.011						.39
Sept. 22..	1.018	2.6	4.3	4.96	3.12	63.09	.50
Sept. 23..	1.018	2.6	3.7	4.09	2.31	56.48	1.07
Sept. 24..	1.021	3.0	4.6	4.66	2.67	57.30	1.34
Sept. 26..	1.021	3.0	4.3	4.35	2.83	65.06	1.06
Sept. 27..	1.018	2.6	3.8	4.05	1.78	43.46	1.00
Sept. 27..	1.016	2.3	3.4	3.82	2.22	58.12	.96
Sept. 28..	1.021	3.0	4.3	4.55	2.90	63.74	1.29
Sept. 29..	1.016	2.3	3.5	4.12	2.52	61.16	1.05
Oct. 1..	1.015	2.0	3.3	3.98	2.51	63.07	1.14
Oct. 3..	1.011	1.6	2.4	3.49	2.13	62.03	.82
Oct. 3..	1.021	3.0	4.6	5.04	3.27	64.88	1.42
Oct. 4..	1.016	2.3	3.4	4.23	2.54	60.05	1.15
Oct. 4..	1.022	3.2	4.8	5.55	3.51	63.24	1.42
Oct. 5..	1.007	1.0	1.7	2.00	1.26	58.12	.49
Oct. 6..	1.007	1.0	1.5	2.04	1.02	50.00	.33
Oct. 7..	1.006	.9	1.0	1.83	.81	53.38	.30
Oct. 8..	1.013	1.9	2.8	3.33	1.97	59.16	.91

TABLE No. 18.—*Exhausted chip juice*—Continued.

Date.	Specific gravity.	Baumé.	Brix.	Brix (corrected.)	Sucrose.	Purity.	Glucose.
		°	°	°	Per cent.		Per cent.
Oct. 10..	1.018	2.6	4.1	4.40	2.81	63.86	.92
Oct. 10..	1.023	3.3	5.6	6.28	3.90	62.10	1.25
Oct. 11..	1.027	3.8	6.4	6.64	4.23	63.70	1.56
Oct. 11..	1.016	2.3	3.3	3.60	2.31	64.17	.75
Oct. 13..	1.021	3.0	4.6	4.77	2.95	61.85	1.40
Oct. 13..	1.022	3.2	4.9	5.34	3.35	62.75	1.37
Oct. 14..	1.023	3.3	5.1	5.42	3.42	63.10	1.41
Oct. 14..	1.019	2.7	4.2	4.82	3.14	65.14	1.02
Oct. 15..	1.018	2.6	4.1	4.35	2.72	62.53	1.04
Oct. 17..	1.039	1.3	1.9	2.23	1.49	66.81	.42
Oct. 17..	1.009	1.3	1.7	2.14	1.29	60.28	
Oct. 18..	1.006	.9	1.1	1.57	.93	59.23	.29
Oct. 19..	1.016	2.3	4.5	5.03	2.54	50.30	.85
Oct. 20..	1.017	2.4	3.8	4.21	2.89	67.22	.94
Oct. 21..	1.013	1.9	2.9	3.28	2.01	61.28	.79
Oct. 21..	1.021	3.0	4.9	5.25	3.11	59.24	1.29
Oct. 22..	1.013	1.9	2.6	2.87	1.87	65.85	.81
Oct. 24..	1.021	3.0	4.8	5.26	2.76	52.47	.65
Oct. 25..	1.014	2.0	3.2	3.43	1.75	51.01	1.16
Oct. 26..	1.014	2.0	3.4	3.87	1.91	49.35	1.43
Oct. 27..	1.017	2.4	3.0	4.10	2.73	65.18	1.18
Oct. 27..	1.020	2.9	4.5	4.87	3.40	69.82	1.31
Oct. 29..	1.013	1.9	3.1	3.40	2.48	72.94	.84
Oct. 31..	1.015	2.2	3.5	3.67	2.47	64.31	1.08
Oct. 31..	1.023	3.3	5.3	5.53	3.09	51.07	1.62
Nov. 1..	1.023	3.3	5.4	5.45	3.48	62.02	1.41
Nov. 2..	1.024	3.4	5.4	5.43	3.60	66.30	1.43
Nov. 3..	1.019	2.7	4.2	4.48	2.86	63.81	
Nov. 8..	1.019	2.7	4.4	4.56	2.97	62.94	1.14
Means ..	1.016	2.3	3.61	4.03	2.46	61.04	.98
Maxima.	1.027	3.8	6.4	6.64	4.23	72.94	1.62
Minima.	1.006	.9	1.0	1.33	.81	43.46	.30

In Table No. 18 is shown the composition of the juices expressed from the chips as discharged from the battery. The total sucrose in the fresh-chip juice, as shown in Table No. 16, was 8.93 per cent. There was left in the juice of the discharged chips 2.46 per cent. The juice remaining in the chips suffers a slight dilution during the process of diffusion, but for comparative purposes the quantity of juice in the chips before and after diffusion may be taken as the same.

In this case the percentage of juice extracted is $8.93 - 2.46 = 6.52$ per cent. The percentage of extraction, therefore, based on the percentage of sucrose in juices from fresh and discharged chips, is 72.6. This is about the average extraction of good milling in Louisiana, but is better than the results obtained by milling sorghum. As already stated, the efficiency of the apparatus was greatly increased by some changes made after the season was over.

TABLE NO. 19.—*Sirup (thick juice).*

Date.	Specific gravity.	Baumé	Brix.	Brix (corrected).	Sucrose.	Purity.	Glucose.
		°	°	°	Per cent.		Per cent.
Sept. 8...	1.136	17.5	31.4	32.16	18.67	58.05	
Sept. 9...	1.138	17.7	34.4	31.80	18.47	57.97	
Sept. 10...	1.141	22.3	40.7	41.12	21.20	51.70	
Sept. 12...	1.122	15.9	28.8	29.64	16.81	56.71	
Sept. 13...	1.131	16.9	30.8	31.48	17.45	55.43	
Sept. 17...	1.124	16.1	28.8	28.83	15.74	54.60	8.01
Sept. 19...	1.124	16.6	29.5	30.08	16.60	55.18	8.49
Sept. 19...	1.145	18.5	33.4	33.94	18.22	53.71	10.45
Sept. 20...	1.145	18.5	33.5	34.05	17.38	51.04	10.20
Sept. 20...	1.160	20.8	37.9	38.37	21.00	54.77	
Sept. 21...	1.154	19.5	36.0	36.69	23.07	62.48	7.44
Sept. 21...	1.149	18.9	34.2	34.74	23.00	66.21	7.26
Sept. 22...	1.164	20.6	37.6	38.20	25.51	66.66	7.64
Sept. 23...	1.150	19.1	34.8	35.15	19.25	54.77	8.46
Sept. 24...	1.162	20.4	37.1	37.20	20.56	55.27	9.52
Sept. 26...	1.122	15.9	28.6	28.68	16.90	58.92	5.97
Sept. 27...	1.149	19.0	34.6	34.83	20.03	57.56	9.10
Sept. 27...	1.110	14.5	36.2	26.40	15.43	50.96	6.87
Oct. 1...	1.118	15.4	27.5	28.55	17.13	60.00	9.24
Oct. 3...	1.105	13.9	24.5	25.57	15.84	61.95	6.05
Oct. 3...	1.086	11.0	24.0	24.82	12.32	49.64	6.10
Oct. 4...	1.110	14.5	28.0	26.60	15.41	58.05	7.79
Oct. 4...	1.155	19.6	33.4	35.91	21.00	58.64	9.10
Oct. 4...	1.099	12.2	23.2	23.23	12.05	61.67	5.53
Oct. 6...	1.102	13.5	24.4	24.70	16.25	65.79	5.60
Oct. 7...	1.098	13.1	23.1	23.52	13.42	57.10	6.31
Oct. 8...	1.087	11.7	20.6	21.28	11.69	54.93	6.50
Oct. 10...	1.154	19.5	35.0	35.74	22.70	63.68	8.38
Oct. 11...	1.115	15.1	26.8	26.98	18.65	60.13	6.32
Oct. 11...	1.140	18.0	32.2	32.52	20.98	64.51	7.46
Oct. 13...	1.172	21.4	39.2	39.30	22.80	58.17	9.70
Oct. 13...	1.138	17.7	32.3	32.55	19.00	64.37	8.32
Oct. 14...	1.149	19.0	34.5	34.89	21.32	61.11	8.70
Oct. 14...	1.147	18.8	34.1	34.65	20.89	60.29	8.86
Oct. 15...	1.132	17.0	30.9	31.10	18.78	60.39	7.91
Oct. 17...	1.083	11.2	19.5	19.88	13.73	64.03	3.81
Oct. 17...	1.085	11.5	19.9	20.55	14.04	68.32	
Oct. 18...	1.134	17.3	31.2	31.84	20.80	65.33	6.38
Oct. 20...	1.171	21.3	39.0	39.59	23.31	58.88	10.12
Oct. 20...	1.144	18.4	33.8	34.15	20.44	59.85	7.95
Oct. 21...	1.121	15.8	28.3	28.62	15.15	62.94	7.59
Oct. 21...	1.154	19.5	35.3	35.60	19.10	53.82	10.82
Oct. 22...	1.163	20.6	37.4	37.54	18.55	49.42	10.70
Oct. 24...	1.183	22.5	41.4	42.02	24.86	59.16	
Oct. 25...	1.131	16.9	30.6	30.99	15.82	51.05	8.34
Oct. 26...	1.126	16.3	29.5	30.07	10.78	35.84	12.94
Oct. 27...	1.158	19.9	36.3	36.35	21.73	59.78	10.93
Oct. 27...	1.139	17.8	32.2	33.17	19.72	59.45	9.58
Oct. 29...	1.132	17.0	31.7	32.09	17.29	53.88	10.13
Oct. 31...	1.189	23.1	42.0	42.00	21.8	51.83	14.45
Oct. 31...	1.118	15.4	27.7	28.20	15.07	53.44	8.83
Nov. 1...	1.175	21.7	39.6	39.82	20.64	51.83	15.70
Nov. 2...	1.192	23.4	43.1	43.16	25.26	58.50	12.27
Nov. 3...	1.156	19.7	35.8	35.98	21.07	58.28	
Nov. 8...	1.159	20.0	30.4	30.30	21.26	58.57	10.73
Means...	1.138	17.7	31.99	32.40	18.68	57.65	8.67
Maxima.	1.192	23.4	43.1	43.16	25.26	68.32	15.70
Minima.	1.083	11.2	19.5	19.48	10.78	35.84	3.81

The diffusion juice at Rio Grande, without any treatment whatever, was conducted directly to an open pan and concentrated to a thin sirup.

The disastrous effects of this treatment are shown by the data of Table No. 19. The evaporation of sugar juices in an open pan is to be condemned for lack of economy; but such treatment, before neutralizing the free acids of the juice, must also necessarily invert a large portion of the sucrose.

The glucose per hundred of sucrose in the normal juice at Rio Grande was 36.06; in the sirup it was 46.38.

The pan on which the concentration took place was shallow and furnished with steam-pipes. The liquor ran rapidly through, otherwise the inversion would have been much greater.

TABLE NO. 20.—*Masse cuites*, Rio Grande, N. J.

Number.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5336	18.37	5.29	23.33	49.90	52.03
5398	16.13	3.22	20.65	58.97	60.71
5399	17.89	3.32	22.47	51.10	56.42
5400	21.32	5.65	24.55	55.47	54.41
5401	19.90	4.21	26.24	51.30	53.97
5427	17.40	4.92	23.45	55.45	55.11
Averages.	18.50	4.44	23.45	53.70	55.44

Table No. 20 shows that no further inversion has taken place by evaporating the sirup in the vacuum pan. Only a small number of samples of *masse cuite* were obtained, since it required a long working of the battery to furnish enough sirup for a strike. Moreover, no samples of *masse cuite* were taken until Mr. Edson took charge of the analytical work. The data of Table No. 20 are therefore not strictly comparable with those of Table No. 19.

The *masse cuites* at Rio Grande were placed in wagons and kept in the crystallizing room, at the proper temperature, for several days, before being sent to the centrifugal machines. The first and second sugars were thus obtained as one product.

By reason of the omission of clarification the sugar was dried with extreme difficulty. Indeed it was found impossible to dry it so as to make a granular product. The gum, glucose, and other impurities kept it in the form of a waxy mass. A glance at the data of Table No. 21 will show the character of the sugar made. A sugar which still contains 13.08 per cent. of reducing sugar would be regarded with grave suspicion by refiners.

The character of the sugar shows the necessity of careful defecation and clarification. Sorghum juices especially, when worked for sugar, should be as nearly neutral as possible, and great care should be exercised to remove all the scums and to allow suspended matters to settle.

TABLE NO. 21.—*Raw sugars, Rio Grande, N. J.*

Number.	Moisture..	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5326	4.61	2.48	12.12	80.3	82.11
5327	6.74	3.75	16.94	67.7	70.65
5328	4.78	2.94	13.02	76.0	77.11
5330	6.67	3.00	14.25	75.0	76.88
5331	3.92	2.71	13.23	69.7	72.79
5332	5.18	2.52	13.13	78.8	77.38
5333	5.11	2.83	13.33	78.4	76.33
5334	5.11	2.69	12.85	73.8	71.95
5359	3.08	3.08	16.78	72.5	72.39
5361	4.41	2.00	13.98	78.2	77.63
5367	5.81	1.54	11.00	81.0	79.77
5368	4.77	1.14	8.20	85.6	84.49
5369	8.40	1.72	12.58	77.2	75.97
5396	5.40	2.01	11.75	80.0	79.61
5397	6.33	2.02	13.15	76.8	77.73
5428	5.30	3.29	13.48	79.2	78.01
Averages..	5.54	2.48	13.08	76.9	76.93

The molasses made at Rio Grande shows the unusual phenomenon of a larger percentage of reducing sugar than of sucrose. This is chiefly due to the fact that it contained so large a quantity of water that it was partly fermented before the analysis was made. The samples stood in the laboratory from October, 1887, to February, 1888; and during this time suffered some inversion.

No. 5342, Table No. 22, is an extreme instance of this inversion. No. 5365 is also an anomalous sample, the data showing some fault of analysis which was not discovered until the tabulation was made. The proportion of sucrose in this sample is entirely too large.

For further data concerning the composition of the molasses consult Table No. 22.

TABLE NO. 22.—*Molasses, Rio Grande, N. J.*

Number.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5335	41.44	6.36	32.35	20.2	23.74
5337	30.14	6.47	33.65	26.6	26.08
5338	29.49	6.12	35.12	26.1	27.92
5340	29.54	6.16	34.68	25.4	27.11
5341	39.17	5.31	32.70	23.0	23.26
5342	40.54	5.49	39.70	11.8	14.44
5360	29.43	6.85	37.05	26.4	27.97
5362	39.12	4.28	35.45	22.5	28.92
5363	36.64	5.32	31.65	38.2	33.91
5364	40.11	5.66	30.21	21.1	23.43
5365	32.32	3.28	28.95	49.5	45.92
5394	30.10	4.81	34.70	26.2	31.53
5395	31.38	3.88	31.05	27.3	30.84
5429	30.98	6.50	35.30	26.6	29.19
Averages..	31.31	5.46	33.75	26.5	28.20

RECRYSTALLIZED SUGARS.

In order to fit the raw sugars for market they were melted and reboiled in the vacuum pan.

The composition of these recrystallized sugars is about the same as seconds from sugar cane. The mean percentage of sucrose is 90.7, while the percentage of glucose remains abnormally high.

The analyses of these sugars are found in Table No. 23.

TABLE NO. 23.—*Recrystallized sugars, Rio Grande, N. J.*

Number.	Molature.	Ash.	Glucose.	Sucrose. direct.	Sucrose indirect.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5430	4.12	.64	4.84	92.5	90.76
5431	5.01	.90	8.58	85.1	83.65
5432	4.70	.91	6.54	91.5	89.69
5433	5.84	.32	8.60	92.5	91.37
5444	3.38	.40	2.74	93.5	92.82
5437	3.98	.83	5.93	91.3	89.59
5438	5.37	1.11	0.26	89.0	80.57
5440	3.08	.67	4.13	91.5	90.31
5441	4.20	.67	4.93	91.2	90.08
5442	3.85	.84	5.14	89.0	86.12
Averages...	4.10	.73	5.77	90.7	89.10

TABLE NO. 24.—*Nitrogenous bodies in cane juice.*

Number.	Nitrogen.	Albuminoids.	Number.	Nitrogen.	Albuminoids.
	<i>Per cent.</i>	<i>Per cent.</i>		<i>Per cent.</i>	<i>Per cent.</i>
276	.072	.3250	403	.020	.1250
277	.045	.2813	413	.017	.1062
278	.078	.3625	431	.033	.5813
279	.040	.2500	471	.012	.0750
280	.040	.3663	472	.017	.1061
281	.048	.3000	480	.023	.1438
290	.040	.3063	481	.027	.1688
292	.052	.3250	487	.023	.1375
293	.041	.2503	488	.025	.1563

TABLE NO. 25.—*Nitrogenous bodies in diffusion juice.*

Number.	Nitrogen.	Albuminoids.
	<i>Per cent.</i>	<i>Per cent.</i>
282	.023	.1434
405	.014	.0835
415	.013	.0813
433	.051	.3175
483	.010	.1000

TABLE NO. 26.—*Nitrogenous matter in diffused chip juice.*

Number.	Nitrogen.	Albuminoids.
	<i>Per cent.</i>	<i>Per cent.</i>
281	.008	.0500
473	.009	.0563
482	.012	.0750
489	.014	.0875

The most encouraging feature connected with the Rio Grande experiments is not found in the composition of the cane so much as in the quantity of it which can be grown per acre. The large tonnage obtained enabled Mr. Hughes to get more sugar per acre with 72 per cent. extraction than was made at Fort Scott with 93 per cent. With a good extraction in the battery, the yield at Rio Grande could have been increased fully 20 per cent.

ANALYTICAL WORK AT MAGNOLIA, LA.

The analytical work at Magnolia was divided into three classes, viz :

- (1) A study of the composition of the juices from the mill and a partial chemical control of the operation of the factory.
- (2) A complete chemical control of the experiments in diffusion.
- (3) Miscellaneous work.

The chemical work was done chiefly by Messrs. Crampton and Fake. During the latter part of the season Dr. Crampton was absent, and the control work was done solely by Mr. Fake. The miscellaneous work I did myself, assisted part of the time by Mr. Fake.

The regular chemical work began on the 4th of November, 1887, and ended January 19, 1888.

In sampling mill juices a measured portion was taken from each of six clarifiers, representing the average composition of the juice from 18 tons of cane. In comparative work, the samples were taken as nearly as possible from the same body of juice in different stages of concentration. The samples for the diffusion work were taken as at Fort Scott and Rio Grande.

MILL JUICES.

During the first few days of the season the juices from the mill were run through a sulphur box, where they were saturated with sulphurous dioxide. They then passed through a heater to the clarifiers and thence to the quadruple effect and strike pan without the use of animal char. This method of treatment was abandoned after a short trial, and no further sulphur was used except in one of the diffusion trials.

In Table No. 27 are found the analytical data obtained during this time.

TABLE NO. 27.—*Mill juices sulphured.*

Date.	No.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	Per cent.	Per cent.	
Nov. 2.....	4	8.8	15.9	12.93	1.11	81.32
Nov. 3.....	6	9.6	17.4	14.41	1.14	82.81
Nov. 3.....	8	9.0	16.23	12.87	1.01	78.68
Nov. 4.....	10	9.0	16.2	13.11	1.11	80.92
Nov. 4.....	12	8.9	16.03	12.63	1.17	78.79
Maxima.....		9.6	17.4	14.41	1.17	82.81
Minima.....		8.8	15.9	12.63	1.01	78.68
Means.....		9.08	16.35	13.19	1.11	80.50

A comparison of the sulphured and clarified juices was also made; but the duration of the use of sulphur was not long enough to give conclusive data. It would appear from the results of the analyses in Table No. 28 that the process of clarification tended to lower the purity of sulphured juices; an apparent fact which more extended investigation would probably modify.

TABLE No. 28.—*Mill juices.—Comparative samples of sulphured and clarified.*

Date.	Sulphured.						Clarified.					
	Number.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.	Number.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.
Nov. 2.....	4	8.8	15.90	12.03	1.11	81.32	5	9.1	16.51	13.28	1.28	80.43
Nov. 3.....	6	9.6	17.40	14.41	1.14	82.81	7	9.6	17.31	14.31	1.10	82.66
Nov. 4.....	10	9.0	16.20	13.11	1.11	80.92	11	9.4	16.97	13.56	1.20	77.90
Maxima ..	.....	9.6	17.40	14.41	1.14	82.81	.....	9.6	17.31	14.31	1.28	82.66
Minima ..	.....	8.8	15.90	12.03	1.11	80.92	.....	9.1	16.51	13.28	1.10	77.90
Means ..	.....	9.13	16.50	13.48	1.12	81.68	.....	9.37	16.93	13.72	1.19	80.83

The daily analyses of the mill juices are recorded in Table No. 29. The variations in the percentage of sucrose were caused by the character of the soil in which the cane was grown. The front lands gave uniformly a cane richer in sucrose than the low lands back from the river. Especially in new back land with a high tonnage was this deficiency noticed.

The mean results show a juice rich in sucrose, poor in reducing sugar, and of satisfactory purity.

TABLE No. 29.—*Mill juices.*

Date.	Number.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	Per cent.	Per cent.	
Nov. 8....	18	8.9	16.00	12.78	1.23	79.87
Nov. 9....	22	7.9	14.30	10.85	1.11	75.87
Nov. 9....	24	9.1	16.36	13.55	.85	82.76
Nov. 10....	26	8.8	15.90	13.22	.88	83.14
Nov. 11....	31	8.9	16.10	12.27	1.08	79.31
Nov. 12....	35	8.7	15.67	12.35	.94	78.81
Nov. 31....	45	8.9	15.97	12.39	1.55	77.58
Nov. 14....	48	8.9	15.97	12.63	1.42	79.08
Nov. 15....	52	8.5	16.33	13.25	1.15	81.13
Nov. 16....	53	8.6	16.57	13.25	1.08	79.66
Nov. 17....	61	9.3	16.93	13.68	1.18	81.28
Nov. 18....	66	9.25	16.73	13.58	1.05	81.11
Nov. 20....	74	9.4	16.93	13.83	1.04	81.69
Nov. 21....	78	9.5	17.16	14.29	.93	83.27
Nov. 22....	83	9.5	17.17	14.94	.65	87.01
Nov. 23....	90	9.2	16.63	14.07	.66	84.56
Nov. 24....	94	9.4	16.93	14.00	.76	82.69
Nov. 26....	100	9.1	16.56	13.79	.79	82.66
Nov. 27....	106	9.25	16.70	13.44	.88	80.48
Nov. 28....	111	8.3	14.07	12.13	.82	81.03
Nov. 29....	114	9.4	16.91	14.09	.73	83.37
Nov. 29....	116	9.5	17.17	14.46	.78	84.21
Nov. 30....	120	8.0	16.41	13.90	.81	84.75
Dec. 1....	125	9.7	17.50	14.74	.72	81.22
Dec. 2....	133	9.5	17.23	14.85	.68	80.18
Dec. 3....	139	9.25	16.73	12.98	.65	77.04
Dec. 3....	145	8.50	15.28	13.03	.....	85.27
Dec. 5....	156	9.1	16.44	13.87	.72	84.86

TABLE No. 29.—*Mill juices*—Continued.

Date.	Number.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	Per cent.	Per cent.	
Dec. 6.....	160	9.0	16.21	13.50	.75	83.33
Dec. 6.....	162	8.8	15.93	13.37	.70	83.30
Dec. 7.....	166	9.1	16.40	14.16	.70	86.54
Dec. 8.....	168	8.65	15.60	12.57	.93	80.57
Dec. 8.....	172	8.9	16.13	13.55	.72	84.00
Dec. 9.....	174	8.5	15.27	12.18	1.00	79.77
Dec. 10.....	177	8.4	15.24	12.17	1.14	79.85
Dec. 12.....	219	8.3	15.06	12.03	.....	80.01
Dec. 13.....	226	8.15	14.91	11.94	1.01	80.01
Dec. 13.....	227	8.30	14.69	11.72	.....	80.00
Dec. 14.....	230	8.3	15.04	11.84	.92	78.72
Dec. 14.....	231	8.4	15.11	12.13	.87	80.27
Dec. 15.....	236	8.15	14.67	11.76	.88	80.16
Dec. 15.....	238	8.2	14.83	11.61	.84	78.28
Dec. 16.....	239	8.0	14.39	11.33	.94	78.68
Dec. 17.....	243	8.0	14.42	11.33	1.02	78.67
Dec. 17.....	245	8.15	14.69	11.67	.99	79.45
Dec. 18.....	246	8.6	15.51	12.31	1.01	79.87
Dec. 18.....	247	8.4	15.24	12.27	.97	80.51
Dec. 19.....	248	8.4	15.23	12.08	1.16	79.31
Dec. 20.....	252	8.7	16.71	13.04	.86	83.00
Dec. 20.....	254	0.2	16.59	13.68	.69	82.45
Dec. 21.....	256	9.0	16.23	13.97	.64	86.07
Dec. 21.....	259	8.1	14.57	11.66	.78	80.02
Dec. 26.....	269	9.3	16.81	14.54	.....	86.49
Dec. 26.....	270	9.4	17.06	14.78	.45	86.63
Dec. 27.....	271	9.4	17.04	14.81	.44	86.91
Dec. 27.....	272	9.25	16.73	14.31	.52	85.53
Dec. 28.....	275	9.4	17.07	14.92	.44	87.41
Dec. 28.....	279	9.6	17.34	15.09	.51	87.02
Dec. 29.....	281	9.5	17.23	15.32	.43	88.91
Dec. 29.....	285	9.5	17.23	15.18	.40	88.10
Dec. 30.....	297	9.75	17.57	15.40	.41	87.65
Dec. 30.....	306	9.4	17.07	14.72	.53	86.23
Dec. 31.....	310	9.7	17.47	15.33	.47	87.18
Dec. 31.....	316	9.4	16.89	14.64	.57	86.67
Dec. 31.....	326	9.4	17.08	14.75	.49	86.34
Jan. 1.....	331	9.4	17.09	14.61	.68	85.43
Jan. 1.....	333	9.25	16.67	14.10	.....	85.54
Jan. 2.....	334	9.3	16.84	14.87	.55	88.30
Jan. 2.....	338	9.2	16.64	14.59	.59	87.68
Jan. 3.....	342	9.4	17.01	14.67	.54	86.29
Jan. 3.....	344	9.8	17.67	15.55	.38	88.90
Jan. 4.....	345	9.0	17.44	15.28	.44	87.04
Jan. 4.....	350	9.5	17.19	14.82	.46	86.21
Jan. 5.....	351	9.75	17.59	15.33	.43	87.16
Jan. 5.....	354	9.5	17.16	14.92	.47	86.04
Jan. 6.....	356	9.4	16.93	14.82	.09	87.53
Jan. 6.....	361	9.6	17.33	15.26	.55	88.05
Jan. 7.....	364	9.4	16.96	14.55	.57	83.79
Jan. 7.....	365	9.4	17.00	14.89	.59	87.59
Jan. 8.....	367	9.5	17.23	14.76	.60	85.66
Jan. 8.....	368	9.1	16.49	13.79	.70	83.57
Jan. 9.....	372	9.5	17.17	14.20	.64	85.61
Jan. 9.....	373	9.4	16.90	14.41	.65	85.26
Jan. 10.....	377	9.25	16.66	13.98	.72	83.31
Jan. 10.....	378	9.1	16.51	14.02	.67	84.96
Jan. 11.....	382	9.0	16.20	13.87	.82	85.61
Jan. 11.....	384	9.3	16.79	14.48	.83	86.19
Jan. 12.....	389	9.25	16.69	14.26	.69	85.39
Jan. 12.....	390	9.25	16.69	14.73	.96	82.21
Jan. 13.....	396	9.1	16.47	13.83	.79	83.97
Means.....	.....	9.04	16.37	13.69	.77	83.48
Maxima.....	.....	9.80	17.67	15.55	1.55	88.91
Minima.....	.....	7.90	14.30	10.85	.40	75.87

The clarification of the mill juices was made in a simple manner. To the juice, as it entered the clarifier from the heater, a quantity of lime was added, nearly sufficient to neutralize the free acid present. The whole was then boiled and swept until no more dirty foam was formed. It was then allowed to subside for half an hour, and the clear juice drawn off.

The skimmings and sediments were sent to the filter presses. The effect of this method of clarification is shown in Table 30.

TABLE NO. 30.—Comparative samples of raw and clarified juices.

Date.	Raw.						Clarified.					
	Number.	Baume.	Brix.	Sucrose.	Reducing sugar.	Purity.	Number.	Baume.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	Pr. ct.	Pr. ct.			°	°	Pr. ct.	Pr. ct.	
Nov. 8...	18	8.9	16.00	12.78	1.23	79.87	19	9.3	16.79	13.07	1.25	81.41
Nov. 9...	22	7.9	14.30	10.85	1.11	75.87	21	8.7	15.07	12.60	1.12	80.41
Nov. 10...	26	8.8	15.90	13.22	.88	83.14	27	9.25	16.73	14.01	.92	83.74
Nov. 11...	31	8.9	16.10	12.77	1.08	79.31	32	9.0	16.31	13.06	1.12	80.07
Nov. 12...	35	8.7	15.67	12.35	.94	78.81	36	8.9	16.01	13.02	1.20	81.37
Nov. 13...	45	8.9	15.97	12.39	1.55	77.58	46	8.9	15.97	13.19	1.57	82.58
Nov. 14...	48	8.9	15.97	12.63	1.42	79.08	49	9.25	16.68	12.94	1.58	77.58
Nov. 15...	52	8.5	16.33	13.25	1.15	81.13	53	10.0	17.98	14.87	1.21	82.76
Nov. 16...	55	8.6	16.57	13.20	1.08	79.66	56	9.5	17.02	14.21	1.04	83.49
Nov. 17...	61	9.3	16.83	13.68	1.18	81.28	62	10.0	18.10	14.92	1.21	82.43
Nov. 18...	66	9.25	16.73	13.58	1.05	81.11	67	9.55	17.24	14.37	1.08	83.35
Nov. 20...	74	9.4	16.93	13.83	1.04	81.69	75	9.9	17.83	15.13	1.13	84.85
Nov. 21...	78	9.5	17.16	14.29	.83	83.27	79	10.1	18.28	15.64	.95	85.55
Nov. 22...	83	9.5	17.17	14.94	.65	87.01	84	9.8	17.72	15.70	.63	89.11
Nov. 23...	90	9.2	16.63	14.07	.66	84.56	91	9.5	17.17	14.73	.64	85.73
Nov. 24...	94	9.4	16.93	14.00	.76	82.69	95	9.9	17.93	15.25	.72	85.05
Nov. 26...	100	9.1	16.56	13.79	.79	82.66	101	9.75	17.57	14.70	.81	83.66
Nov. 27...	106	9.25	16.70	13.44	.88	80.48	107	9.6	17.38	14.14	.82	81.35
Nov. 28...	114	9.4	16.91	14.09	.73	83.37	115	9.65	17.45	14.84	.70	84.98
Nov. 29...	116	9.5	17.17	14.46	.78	84.21	117	9.8	17.78	15.33	.74	86.22
Nov. 30...	120	8.0	14.41	13.90	.81	84.75	121	9.75	17.63	15.20	.77	86.21
Dec. 1...	125	9.7	17.50	14.74	.72	84.22	126	9.8	17.69	14.72	.75	83.16
Dec. 2...	133	9.5	17.23	14.85	.68	80.18	134	9.9	17.70	15.71	.66	88.26
Dec. 5...	150	9.1	16.44	13.87	.72	81.36	157	9.4	16.94	14.53	.73	85.77
Dec. 6...	160	9.0	16.21	13.58	.75	83.33	161	9.4	17.03	14.48	.70	85.02
Dec. 7...	166	9.1	16.40	14.16	.70	86.34	167	9.1	16.46	14.18	.69	86.14
Dec. 8...	168	8.65	15.60	12.57	.93	80.57	169	8.9	16.07	13.34	.93	83.01
Dec. 9...	174	8.5	15.27	12.18	1.00	79.77	175	8.9	16.03	13.17	1.04	82.16
Maxima.	.....	9.70	17.50	14.94	1.55	87.01	.....	10.1	18.28	15.79	1.58	89.11
Minima.	.....	7.90	14.50	10.85	.65	75.87	.....	8.7	15.97	12.60	.63	77.58
Means	.....	9.02	16.34	13.48	.94	82.01	.....	9.48	17.12	14.85	.95	83.76

The increased density of the clarified juices, and the consequent higher percentage of sucrose, are due to the evaporation which takes place during clarification. The purity of the juices was raised 1.75 points by the process. A slight destruction of reducing sugars also took place.

After clarification the juices were filtered through bone-black. This char had been so long in use that its decolorizing power was partially destroyed. It served, however, as a most excellent mechanical filter, serving to remove suspended matter which would not subside.

The purity of the juice was raised nearly one point by this filtration. A comparative study of raw, clarified, and filtered juices is given in Table No. 31.

TABLE NO. 31.—*Mill juices.—Comparative samples of raw, clarified, and filtered juices.*

RAW.

Date.	Number.	Baume.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 8...	18	8.9	16.00	12.78	1.23	79.87
Nov. 9...	22	7.9	14.30	10.85	1.11	75.87
Nov. 10...	26	8.8	15.90	13.22	.88	83.14
Nov. 11...	31	8.9	16.10	12.77	1.08	79.31
Nov. 12...	35	8.7	15.67	12.35	.94	78.81
Nov. 13...	45	8.9	15.97	12.39	1.55	77.58
Nov. 14...	48	8.9	15.97	12.63	1.42	79.08
Nov. 15...	52	8.5	16.33	13.25	1.15	81.13
Nov. 16...	55	8.6	16.57	13.20	1.08	79.66
Nov. 17...	61	9.3	16.83	13.68	1.18	81.28
Nov. 18...	66	9.25	16.73	13.68	1.05	81.11
Nov. 21...	78	9.5	17.16	14.29	.93	83.27
Nov. 23...	83	9.5	17.17	14.94	.65	87.01
Nov. 23...	90	9.2	16.63	14.07	.66	84.56
Nov. 24...	91	9.4	16.93	14.00	.70	82.69
Nov. 26...	100	9.1	16.56	13.79	.79	82.66
Nov. 27...	106	9.25	16.70	13.44	.88	80.48
Nov. 29...	116	9.5	17.17	14.46	.78	84.21
Nov. 30...	120	8.0	16.41	13.90	.81	84.75
Maxima.....		9.50	17.17	14.94	1.55	87.01
Minima.....		7.90	14.30	10.85	.65	75.87
Means.....		8.95	16.37	13.31	1.00	81.39

CLARIFIED.

Date.	Number.	Baume.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	<i>Per cent.</i>	<i>Per cent.</i>	
Nov. 8...	19	9.3	16.79	13.67	1.25	81.41
Nov. 9...	23	8.7	15.67	12.60	1.12	80.41
Nov. 10...	27	9.25	16.73	14.01	.92	83.74
Nov. 11...	32	9.0	16.31	13.06	1.12	80.07
Nov. 12...	36	8.9	16.01	13.02	1.20	81.87
Nov. 13...	46	8.9	15.97	13.19	1.57	82.59
Nov. 14...	49	9.25	16.68	12.94	1.50	77.58
Nov. 15...	53	10.0	17.98	14.67	1.21	82.70
Nov. 16...	56	9.5	17.02	14.21	1.04	83.49
Nov. 17...	62	10.0	16.10	14.92	1.21	82.43
Nov. 18...	67	9.55	17.24	14.37	1.08	85.35
Nov. 21...	79	10.1	18.28	15.64	.95	85.55
Nov. 22...	84	9.8	17.72	15.79	.63	89.11
Nov. 23...	91	9.5	17.17	14.72	.64	85.73
Nov. 24...	95	9.9	17.93	15.25	.72	85.03
Nov. 26...	101	9.75	17.57	14.70	.81	83.66
Nov. 27...	107	9.6	17.38	14.14	.82	81.35
Nov. 29...	117	9.8	17.78	15.33	.74	80.22
Nov. 30...	121	9.75	17.63	15.20	.77	86.21
Maxima.....		10.1	18.28	15.79	1.57	89.11
Minima.....		8.7	15.67	12.60	.63	83.74
Means.....		9.50	17.16	14.30	1.02	82.21

FILTERED.

Date.	Number.	Baumé.	Brix.	Sucrose.	Reducing sugar.	Purity.
		°	°	Per cent.	Per cent.	
Nov. 8....	20	9.4	16.96	14.00	1.26	82.54
Nov. 9....	21	9.0	16.23	13.01	1.12	80.16
Nov. 10....	28	8.75	15.73	12.40	1.01	78.76
Nov. 11....	33	9.3	16.83	13.62	1.03	80.93
Nov. 12....	37	9.1	16.47	13.29	1.16	80.69
Nov. 13....	47	9.2	16.56	13.25	1.39	80.61
Nov. 14....	50	9.55	17.27	13.25	1.60	76.72
Nov. 15....	54	9.6	17.38	15.16	1.13	87.22
Nov. 16....	57					
Nov. 17....	63	9.6	17.30	14.29	1.18	82.60
Nov. 18....	68	9.8	17.63	14.27	1.14	80.94
Nov. 21....	80	10.0	18.09	15.50	.91	85.03
Nov. 22....	85	10.2	18.39	16.25	.51	88.31
Nov. 23....	92	9.9	17.67	15.61	.54	87.52
Nov. 24....	96					
Nov. 26....	102	9.6	17.30	14.63	.77	81.50
Nov. 27....	108	9.9	17.90	14.89	.72	83.13
Nov. 29....	118	9.7	17.47	15.45	.72	88.44
Nov. 30....	122	9.75	17.50	15.04	.67	85.77
Maxima.....		10.2	18.39	16.25	1.60	88.44
Minima.....		9.0	15.73	12.40	.51	76.72
Means.....		9.55	17.23	14.35	.99	83.17

Samples of the sirup issuing from the Yaryau quadruple effect pan were taken from time to time, and the results of the analyses of these sirups are shown in Table No. 32.

TABLE NO. 32.

Date.	Number.	Brix corrected.	Baumé corrected.	Purity.	Sucrose.	Glucose.
					Per cent.	Per cent.
Nov. 3..	9	54.37	29.45	81.42	44.27	4.48
Nov. 4..	15	53.34	28.90	80.43	42.9	4.86
Nov. 12..	38	37.45	20.53	80.91	20.3	2.89
Nov. 18..	69	50.90	27.70	82.32	41.9	3.80
Nov. 22..	86	51.56	28.00	87.08	44.9	2.31
Nov. 23..	93	54.18	29.40	85.46	46.3	2.01
Nov. 26..	103	47.60	25.00	76.03	36.2	2.87
Nov. 28..	112	51.53	28.00	85.19	43.9	2.50
Dec. 2..	136	50.19	27.30	89.66	45.0	
Dec. 4..	151	52.26	28.35	86.68	45.3	2.41
Dec. 6..	163	50.66	27.53	80.46	43.8	2.02
Dec. 8..	170	52.04	28.54	85.49	45.0	2.46
Dec. 15..	237	48.86	26.60	81.87	40.0	3.16
Dec. 20..	253	48.74	26.50	78.17	38.1	3.65
Dec. 22..	260	46.29	25.20	85.98	39.8	
Dec. 28..	276	48.79	26.60	80.57	43.7	1.36
Jan. 2..	325	50.59	27.50	88.56	44.8	1.64
Jan. 4..	346	50.42	27.40	88.85	44.8	1.60
Means.....		50.02	27.19	84.45	42.28	2.75

The samples of *masse cuites* were placed in bottles and sent to the laboratory for analysis. In addition to the determinations of the sucrose by direct and double polarization it was also estimated by copper solution.

The mean result of this latter estimation is slightly below the mean of the direct readings. In individual cases a marked variation between the chemical and optical methods is noticed. The percentage of ash, compared with sorghum *masse cuites*, is small.

For details see Table No. 33.

TABLE NO. 33.—*First masse cuites* (mill), Lawrence, La.

Number.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by copper.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5715	9.69	2.33	8.06	78.70	78.37	74.94
5717	9.06	2.05	8.75	77.03	78.74	75.02
5719	6.30	2.31	7.03	81.00	80.77	78.58
5720	9.12	2.64	7.31	76.50	76.98	74.80
5721	8.65	2.03	7.06	78.00	77.44	75.04
5727	17.88	4.06	12.36	70.00	71.04	71.48
5729	13.51	2.01	4.56	81.30	80.00	78.17
5730	9.40	-----	5.53	75.80	77.71	76.78
5731	8.52	2.41	4.00	80.50	81.06	80.32
5734	10.79	2.79	5.91	74.10	75.58	76.13
5740	7.85	-----	6.54	75.90	76.88	76.82
5743	8.47	3.96	6.94	-----	-----	78.43
5748	8.21	2.58	4.79	79.00	80.23	80.71
5749	9.05	3.10	5.13	76.80	78.45	78.40
5754	10.71	2.17	4.78	77.10	78.08	78.30
5755	10.67	2.03	3.65	80.00	80.92	78.95
5762	10.73	2.06	4.29	77.70	79.31	82.14
5763	9.29	1.94	3.98	70.00	79.39	78.40
5767	8.84	2.14	3.79	83.30	84.31	70.50
5769	-----	-----	4.26	82.20	83.00	78.99
5770	10.54	2.12	4.46	70.00	80.61	79.38
5773	9.03	2.37	4.75	78.10	79.84	79.10
5776	9.39	2.35	4.83	79.30	80.91	79.53
5780	9.48	2.48	5.26	78.00	80.15	78.28
5783	9.84	2.50	5.21	78.10	79.54	76.75
Averages ...	9.79	2.53	5.73	78.21	79.05	77.46
Mean purity.	-----	-----	-----	-----	-----	87.63

The high purity of the *masse cuites*, as shown in Table No. 33, as compared with the juices and sirups, may be accounted for as follows:

In the latter the percentage of total solids was calculated from the readings of the saccharometer; in the former by drying and direct weighing. The results of last season's work, both with sugar-cane and sorghum juices, show that by the use of the spindle the percentage of total solids found is always too high. The purity of the juices, therefore, is higher than indicated by the analyses. A note on the subject will be made subsequently.

The direct polarization of the first sugars is given in Table No. 34.

In these sugars there was only a trace of glucose, but no attempt was made to estimate its quantity, not even by Soldaini's reagent (carbonate of copper dissolved in acid carbonate of potassium). For the same reason a double polarization was not necessary.

TABLE NO. 34.—*First sugars*, Lawrence, La.

Date.	No.	Sucrose.	Date.	No.	Sucrose.
		<i>Per cent.</i>			<i>Per cent.</i>
Nov. 4.....	14	96.5	Dec. 16.....	240	97.0
Nov. 12.....	34	98.6	Dec. 19.....	249	97.0
Nov. 16.....	58	98.2	Dec. 22.....	262	97.7
Nov. 18.....	59	*97.3	Dec. 28.....	280	98.5
Nov. 20.....	76	98.8	Jan. 2.....	337	97.6
Nov. 20.....	77	98.6	Jan. 3.....	343	*98.0
Nov. 22.....	80	97.5	Jan. 5.....	353	96.8
Nov. 26.....	105	97.0	Jan. 6.....	362	98.4
Nov. 27.....	109	97.6			
Nov. 28.....	110	98.5	Mean		97.8
Dec. 1.....	130	98.0			

*Cut strike.

FIRST MOLASSES.

Samples of molasses from the first sugars were taken from time to time from the large tank into which the molasses was pumped after issuing from the centrifugals. These samples therefore represent fairly well the composition of the first molasses for the entire season. The same remarks apply to the mean purity as were made in respect of the purity of the *masse cuites*—the water in the molasses having been determined by direct weight.

The mean determinations by the copper method agree well with the results of double polarization, although, as in the case of the *masse cuites*, the individual deviations are large. The presence of invert sugar, optically active, is clearly shown by the differences in single and double polarization.

Analyses follow in Table No. 35.

TABLE NO. 35.—*First molasses, Lawrence, La.*

Number.	Molature.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5718	31.25	4.32	13.65	47.20	46.97	44.89
5724	28.84	8.92	14.23	45.50	48.21	46.89
5728	39.65	4.48	16.18	33.00	33.33	-----
5741	29.39	6.12	-----	-----	-----	-----
5744	-----	8.43	14.63	32.80	36.70	34.05
5745	30.70	7.48	9.43	46.20	45.34	43.83
5747	29.30	5.64	-----	-----	-----	-----
5753	-----	4.87	4.25	54.90	52.46	48.09
5760	-----	-----	10.58	44.10	55.14	56.26
5766	18.82	7.15	13.34	46.20	49.77	50.80
5768	22.95	4.49	8.53	55.50	58.46	59.26
5772	20.94	4.52	8.28	58.50	61.98	-----
5775	23.30	5.29	9.80	53.90	57.27	57.72
5778	23.08	4.32	9.52	55.20	59.12	58.44
5781	23.27	4.84	10.05	55.10	58.85	67.70
Averages....	26.79	5.42	10.96	48.28	51.05	51.56
Mean purity.	-----	-----	-----	-----	-----	69.73

SECOND MASSE CUIITE.

The samples of second *masse cuite* analyzed were all, with one exception, taken at the last of the season, when the juice was particularly rich in sucrose. They show therefore a higher purity than the mean of the first molasses. The data in Table No. 36 furnish a further illustration of the fact that the molasses from rich juices have a higher purity than that from the poorer sorghum. These facts are suggestive of the idea that the solids not sucrose in sorghum are less melassigenic than those in sugar-cane.

TABLE NO. 36.—*Second masse cuites, Lawrence, La.*

Date.	Number.	Molsture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Nov. 11	5723	5.49	4.25	13.33	67.10	69.84	68.68
Jan. 2	5761	10.51	4.08	7.31	63.20	72.27	73.20
Jan. 5	5764			8.30	68.00	70.60	
Jan. 6	5765	7.15	4.12	5.92	73.00	75.02	75.70
Jan. 12	5784	7.78	4.48	9.69	67.90	69.77	61.81
Averages		7.73	4.23	8.91	69.04	71.54	69.85
Mean purity							77.53

SECOND MOLASSES.

The samples of second molasses were taken from large cisterns and represent fairly well the character of this product for the entire season.

The most striking feature of the mean composition of this molasses is the purity co-efficient. After two crystallizations the molasses at Magnolia still had a purity-number only a little below the first *masse cuite* at Fort Scott, and almost identical with that of the first *masse cuite* at Rio Grande.

This number shows the possibility of a large yield of third sugars.

TABLE NO. 37.—*Second molasses, Lawrence, La.*

Date.	Number.	Molsture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Nov. 19	5725	16.33	6.70	21.93	41.70	46.43	44.46
Dec. 24	5761	24.27	7.46	16.60	34.70	38.81	34.81
Jan. 6	5766	18.82	7.15	13.34	46.20	49.77	50.89
Averages		19.81	7.10	17.29	40.87	45.01	47.37
Mean purity							56.13

TABLE NO. 38.—*Second sugars, Lawrence, La.*

Date.	Number.	Sucrose.
		<i>Per cent.</i>
Nov. 12	44	85.6
Dec. 4	152	80.6
Dec. 8	171	91.8
Dec. 20	235	87.0
Dec. 24	266	85.8
Dec. 25	268	87.3
Jan. 4	349	90.2
Average		89.76

CHEMICAL CONTROL OF THE DIFFUSION EXPERIMENTS.

The following data respecting the diffusion experiments are abstracted from Bulletin 17, pp. 83-89:

The first results from the experiments were obtained from the run of December 3, 1887.

The juice was treated with .3 per cent. its weight of lime, and after the precipitation of the lime with carbonic dioxide, an amount of lignite equal to 10 per cent. of the weight of the sugar present was added.

The juice filtered readily through the presses, forming firm, hard cakes. The filtered juice was treated with phosphate of soda, 15 pounds of this salt being added for each 5,000 pounds of juice.

The phosphate produced an abundant flocculent precipitate, which filtered easily through the twin filter presses, giving a juice of remarkable limpidity. The *masse cuite*, however, was dark, and the molasses much inferior in color to that made by the use of bone-black and ordinary clarification.

The phosphate of soda did not produce as favorable results as had been expected, and its further use was discontinued.

Following are the data obtained in the first run:

TABLE NO. 39.—First diffusion run, December 3, 1887.

	Total solids.	Sucrose.	Glucose.
Juice from chips:	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First	15.20	12.01	.96
Second	14.45	11.92	1.00
Third	15.45	12.84	1.02
Average	15.03	12.26	.99
Diffusion juice:			
First	10.88	8.88	.83
Second	10.40	8.65	.74
Average	10.64	8.76	.78
Exhausted chips:			
First sample		.51	
Second sample		.76	
Third sample		.91	
Average		.73	
Carbonatated juice	11.09	9.20	.70
Waste water			.12
Semi-sirup	51.80	42.20	3.39
First sugar		97.50	
Molasses from first sugar	76.30	45.00	11.11
Second sugar		91.60	

Cane usedtons.. 80.3

First sugar per tonpounds.. 146.1

Second sugar per ton.....do.... 40.1

Total first and second sugarsdo.... 186.2

Third sugardo.... 15.0

Pounds.

The total sugar in the cane at 90 per cent. juice was 220.6

Of this there was obtained 146.1 pounds at 97.50 144.4

And 40.1 pounds at 91.6 36.7

Total pure sucrose obtained 181.1

Left in chips 14.6

Total left in mola-sses and lost in manufacturing 24.9

NOTE.—The third sugar will not be dried until in May or June, 1888. The estimates of third sugar have been made by Mr. E. C. Barthelemy.

EXTRACTION.

The percentage of sucrose left in the spent chips was .73. Sucrose in cane was 11.03 per cent. The per cent. of extraction is therefore $11.03 - .73 = 10.30 \div 11.03 \times 100 = 93.4$.

SECOND TRIAL.

Another trial was made of the diffusion machinery, beginning December 9. Carbonatation was again used, but without lignite or any further treatment. The juice passed directly from the filter presses to the double-effect pan.

The quantity of lime employed was .6 per cent. the weight of the juice. The filtration was perfect. The experiment was remarkable in showing that a perfect defecation can be made with carbonatation with a much smaller percentage of lime than had been supposed necessary.

The *masse cuite* was dark, but the sugar a fair yellow.

Following are the data of the run:

TABLE NO. 40.—Second diffusion run, December 9, 1887.

	Total solids.	Sucrose.	Glucose.
	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Fresh chips:			
First sample	14.06	11.70	1.04
Second sample	15.65	13.64	.70
Third sample	15.70	13.62	.75
Fourth sample	15.50	13.02	.81
Fifth sample	14.00	11.18	1.02
Average	14.98	12.61	.88
Diffusion juice:			
First sample	9.36	7.83	.67
Second sample	8.67	7.25	.58
Third sample	9.68	7.61	.55
Fourth sample	10.40	8.69	.91
Fifth sample	10.20	8.45	.78
Average	9.66	7.96	.69
Carbonatated juice:			
First sample	9.12	7.73	.65
Second sample	8.74	7.35	.57
Third sample	10.20	8.55	.50
Fourth sample	11.40	9.00	.73
Average	9.86	8.16	.61
Exhausted chips:			
First sample		1.58	.....
Second sample		1.69	.....
Third sample		.48	.....
Fourth sample		.32	.....
Fifth sample		.40	.....
Average		.89	.....
Semi-sirup	47.70	38.90	2.96
First sugar		96.60	
Molasses from firsts	72.20	42.40	10.50
Second sugar		87.30	

Yield of first sugar per ton	pounds..	182
Yield of second sugar per ton	do.	43
Cane used	tons.	90
The total sugar in the cane at 90 per cent. juice was	per ton.	226.98
Of these there were obtained 128 pounds at 96.6		123.6
And 43 pounds at 87.3		37.5
Total pure sucrose obtained	per ton.	161.1
Pure sucrose left in chips	do.	17.8
Pure sucrose left in molasses and lost in manufacture	do.	41.1
Third sugar estimated	do.	17.0
Percentage sugar in cane extracted		92.16

The poor yield was due to use of thick chips during the first part of the run, causing a loss of 1.6 per cent. sucrose in the chips.

THIRD TRIAL.

In this run the use of carbonatation and lignite was discontinued. The diffusion juices were treated with sulphur fumes until well saturated. They were then treated with lime and clarified in the usual way.

The clarification took place readily. The quantity of scums was very small, and the sediment subsided rapidly, forming a thin layer on the bottom of the tank, permitting the clear liquor to be easily and completely drawn off. The juice passed at once from the clarifiers to the double effect pan and subsequently received no further purification.

Following are the analytical data obtained :

TABLE No. 41.—*Third diffusion run December 10 and 11, 1888.*

	Total solids.	Sucrose.	Glucose.
Fresh chips :	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First sample	14.39	11.89	.79
Second sample.....	12.77	10.63	.77
Third sample.....	14.49	12.06	.80
Average.....	13.88	11.53	.78
Diffusion juice:			
First sample.....	9.42	7.82	.63
Second sample.....	9.41	7.87	.59
Third sample.....	9.55	7.86	.67
Average.....	9.46	7.85	.63
Sulphured juice:			
First sample.....	9.69	8.17	.66
Second sample.....	9.12	7.53	.58
Average.....	9.40	7.85	.62
Clarified juice:			
First sample.....	9.95	8.21	.67
Second sample.....	9.89	8.06	.63
Third sample.....	10.32	8.39	.71
Average.....	10.05	8.22	.67
Exhausted chips:			
First sample.....		.80	
Second sample.....		.50	
Third sample.....		.77	
Fourth sample.....		.93	
Average.....		.75	
Semi-sirup	44.70	34.60	2.87
First sugar.....		96.30	
Molasses from first sugar.....	72.90	36.70	12.07

First sugar per ton.....pounds.. 143
 Number tons cane used 110

The molasses from the first sugar was boiled to string proof, and put in wagons. A good crystallization of second sugar was secured but, the molasses having been left too acid, a good separation was not secured. Mr. Barthelemy therefore decided to reboil the molasses with some of the product of the mill process, and therefore no statement of the quantity of second sugar can be given. It was estimated at 30 pounds per ton.

The cane from which this run was made was grown on new back land and was the poorest of the whole season.

The percentage of sugar extracted of total sugar in cane was 92.80.

FOURTH TRIAL.

In this run the diffusion juice was treated with lime until almost neutral. It was then boiled, skimmed, and allowed to settle. The scums and sediments were of small volume and were all returned to the battery.

The juice received no other treatment whatever for clarification. It was converted to sirup in a double effect vacuum pan. The capacity of this pan was not quite great enough to evaporate the juice as fast as furnished by the battery. For this reason the run which might have been finished in two days occupied a part of a third day. The quantity of cane worked was 200 tons.

The following is a record of the analytical data obtained :

TABLE NO. 42.—*Fourth diffusion run, December 29, 30, and 31, 1887.*

	Total. solids.	Sucrose.	Glucose.
Juices from fresh chips :	<i>Per ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>
A. M., first day	16.46	14.23	.49
P. M., first day	17.27	15.83	.43
Midnight, first day	17.26	15.12	.43
A. M., second day	17.13	14.84	.45
Midnight, second day	16.97	14.93	.54
A. M., third day	16.19	13.90	.61
P. M., third day	16.26	14.05	.50
Average fresh chip juice for run	16.79	14.60	.49
Diffusion juices :			
First sample, first day	9.72	8.71	.32
Second sample, first day	10.09	9.01	.29
Third sample, first day	11.38	10.16	.30
Fourth sample, first day	11.60	9.81	.53
First sample, second day	11.10	9.87	.32
Second sample, second day	10.92	9.69	.33
Third sample, second day	10.94	9.77	.44
First sample, third day	10.45	9.81	.35
Second sample, third day	10.87	9.69	.38
Average diffusion juice for run	10.78	9.50	.36
Clarified juices :			
Average for first day	10.75	9.34	.32
Average for second day	11.77	10.36	.32
First sample, third day	12.01	10.36	.41
Second sample, third day	11.61	9.78	.38
Third sample, third day	11.25	9.51	.36
Average clarified juice for run	11.48	9.87	.36
Juices from exhausted chips :			
First sample, first day		.52	
Second sample, first day		.61	
Third sample, first day		.88	
First sample, second day		1.12	
Second sample, second day		.72	
Third sample, second day		.95	
First sample, third day		1.09	
Second sample, third day		1.30	
Third sample, third day		1.10	
Average exhausted chip juice for run		.91	
Semi-sirup for first strike	37.37	33.10	.99
Masse culite, first strike		31.20	
First sugar from first strike		38.40	
First molasses from first strike	76.22	51.80	7.76
Semi-sirup for second strike	40.00	35.10	1.19
Masse culite		30.60	
First sugar		33.90	
Molasses from second strike	79.00	55.60	
Average extraction		33.8	
Pounds first sugar per ton		165.5	
Per cent. sugar extracted obtained in firsts		66.2	

Second sugar per ton pounds.. 45.9
 Third sugar per ton (estimated) do. *18.0
 Cane used tons.. 200

* On February 29 I was informed by letter from Governor Warmoth that the third sugars from the fourth run had been dried and weighed, yielding 3,723 pounds, or 18.6 pounds per ton.

FIFTH TRIAL.

The fifth and last run of the diffusion battery was begun on January 14 and finished on the 18th. This trial was made after the milling work had been completed. The diffusion juices were treated precisely the same way as the mill juices had been, and after passing over bone-black were concentrated to slrup in a Yaryan quadruple effect, which has been in use with the mill juices during the manufacturing season.

The working of all the machinery during this final trial was satisfactory, and the even march of the whole work promoted the efficiency of the machinery and the successful manipulation of the juice.

TABLE NO. 43.—Analytical data of fifth run.

No.	Brix.	Sucrose.	Glucose.	No.	Brix.	Sucrose.	Glucose.
Fresh chips:	°	Per cent.	Per cent.	Diffusion juices—	°	Per cent.	Per cent.
397.....	16.87	14.23	.74	continued.			
400.....	16.39	13.45	.87	450.....	9.88	8.12	.42
403.....	16.39	13.79	.89	453.....	10.87	9.00	.38
405.....	17.09	14.73	.68	460.....	9.89	.....	.45
408.....	16.86	12.11	.75	466.....	10.67	8.41	.61
411.....	17.16	14.73	.64	469.....	10.47	8.01	.72
414.....	16.93	14.06	.70	473.....	10.17	8.02	.48
417.....	17.00	14.50	.61	476.....	10.15	7.86	.48
420.....	16.70	13.93	.73	479.....	10.81	7.92	.47
423.....	16.79	14.11	.74	485.....	10.50	8.26	.52
426.....	17.19	14.17	.61	491.....	9.69	7.53	.61
429.....	16.73	14.19	.59				
437.....	17.11	14.55	.61	Maximum.....		9.28	.72
440.....	16.17	13.48	.75	Minimum.....		7.53	.34
443.....	16.17	13.43	.76	Mean.....		8.41	.47
446.....	16.60	13.99	.63				
449.....	16.63	14.39	.65	Exhausted chips:			
452.....	16.77	14.28	.63	399.....		.52	.....
456.....	16.23	13.29	.77	402.....		.21	.....
465.....	16.03	13.70	.76	407.....		.52	.....
468.....	16.07	13.35	.85	410.....		.39	.....
472.....	16.84	14.34	.64	413.....		.53	.....
475.....	16.37	13.54	.82	416.....		.41	.....
478.....	16.51	14.17	.70	419.....		.33	.....
484.....	16.64	14.38	.65	422.....		.42	.....
490.....	16.57	14.52	.69	425.....		.42	.....
				428.....		.55	.....
Maximum.....		14.73	.69	431.....		.42	.....
Minimum.....		12.11	.59	439.....		.50	.....
Mean.....		13.98	.70	442.....		.50	.....
				445.....		.42	.....
Diffusion juices:				448.....		.46	.....
398.....	11.37	9.28	.60	451.....		.69	.....
401.....	10.67	8.66	.64	454.....		.65	.....
404.....	10.61	8.92	.49	461.....		.51	.....
409.....	10.38	8.53	.41	467.....		.42	.....
412.....	11.01	9.10	.45	470.....		.39	.....
415.....	10.91	8.60	.48	474.....		.43	.....
418.....	10.71	8.76	.40	477.....		.54	.....
421.....	10.65	8.77	.40	480.....		.34	.....
424.....	10.57	8.51	.44	486.....		.22	.....
427.....	10.52	8.90	.46	492.....		.48	.....
430.....	10.65	9.05	.32				
438.....	10.27	8.46	.35	Maximum.....		.69	.....
441.....	10.73	8.94	.45	Minimum.....		.21	.....
444.....	10.88	8.99	.42	Mean.....		.44	.....
447.....	9.5	7.68	.34				

The molasses from the first sugars being very rich, the method of reboiling to grain was employed. To this end the molasses of the first strike, having been reduced to 55 to 60 per cent. of total solids, was boiled on a nucleus of first sugar left in the pan from the second strike. In this way all the molasses was boiled to grain with most gratifying results except that from the last strike of the first sugars.

The attempt to boil this to grain did not succeed in giving a *masse cuite* which could be dried with ease. The molasses running from the machines was so thick that it clogged them up. Seven large sugar wagons were filled with this material and set in the hot room.

The sugars made were equal in every respect to those obtained by milling in similar instances. Without counting the second sugar above named, the grained sugar per ton amounted 181.5 pounds. The grained sugars in wagons will yield not less than 7,500 pounds, or 18 pounds per ton.

The third sugars are estimated by Mr. Barthelemy at not less than 16 pounds per ton.

The total yield per ton of the fifth run will reach therefore 215.5 pounds per ton. The number of tons of cane used was 417.

TABLE NO. 44.—*Summary of results.*

Number of run.	Cane.	Mean sucrose in juice.	Mean glucose in juice.	Sugar grained in pan per ton. First sugar.
	<i>Tons.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Pounds.</i>
1.....	80.3	12.26	.99	146.1
2.....	90.0	12.61	.88	128.0
3.....	110.0	11.53	.78	143.0
4.....	200.0	14.60	.49	165.5
5.....	417.0	13.98	.70	181.5

Wagon sugar per ton.		Total sugars per ton.
Second sugar.	Third sugar (estimated).	
<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
40.1	15	201.3
43.0	18	189.0
80.0	12	185.0
45.0	18	229.4
18.0	16	215.5

MASSE CUITES, SUGARS, AND MOLASSES FROM THE DIFFUSION RUNS.

Following are the data of the analyses of the *masse cuites*, sugars, and molasses from the diffusion runs.

In Table No. 45 are the results of examination of samples afforded by the first diffusion run.

TABLE NO. 45.—*First run, juices after carbonatation clarified with sodium phosphate.*

	No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Masse cuite.....	5732	9.20	.....	5.91	75.40	76.96	78.94
	5734	10.79	2.79	5.91	74.10	75.58	76.13
Averages		10.00	2.79	5.91	74.75	76.27	77.54
First sugar.....	5733	0.51	0.48	.....	97.50	.....	.....

TABLE NO. 46.—Carbonatation, second run, diffusion, Lawrence, La.

	No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First masse cuite...	5735	9.53	3.90	6.21	75.7	76.22	76.94
First molasses		.....	.....	10.50	42.4	.....	.....
First sugar.....	5737	.58	.48	.....	96.6	.....	.....
Second sugar.....	5752	3.23	2.83	1.36	87.8	80.49	84.20

TABLE NO. 47.—Juice sulphured, third run, diffusion, Lawrence, La.

	No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Masse cuite	5736	8.42	3.79	6.79	73.9	76.19	76.58
Molasses	5739	34.04	7.53	12.07	36.7	.....	.....
Sugar	5738	.46	.82	.....	96.3	.....	.....

TABLE NO. 48.—Fourth run, clarification by lime, diffusion, Lawrence, La.

	Number.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Masse cuites.....	5756	9.42	2.63	.....	77.40	78.48
	5759	9.27	2.57	.....	.....	.....
Averages.....		9.35	2.60	.....	77.40	78.48
Molasses.....	5758	24.01	5.28	7.77	51.80	.....
Sugar.....	6757	.27	.32	.....	98.4	.....

TABLE NO. 49.—Fifth run, juices bone-blackd, diffusion, Lawrence, La.

	No.	Moisture.	Ash.	Glucose.	Sucrose direct.	Sucrose indirect.	Sucrose by Fehling.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
First masse cuite..	5785	8.83	2.47	5.25	79.3	80.53	80.75
	5787	10.68	2.47	4.36	76.5	78.77	78.80
	5790	12.04	3.49	4.24	73.7	75.33	75.41
Averages.....		10.52	2.81	4.62	76.5	78.21	78.33
First molasses.....	5788	39.59	3.94	9.93	39.0	41.98	43.82
	5789	42.86	3.98	7.78	38.2	41.14	42.79
	5791	31.57	6.71	13.82	48.4	49.79	43.92
Average.....		38.01	4.88	10.51	41.9	44.30	43.51
Second masse cuite	5792	10.21	4.52	7.06	70.9	73.36	77.23
	5789	24.33	7.44	15.30	38.4	43.81	45.82
Second molasses...	5793	.....	7.80	14.50	45.8	51.22	53.14
Averages.....		24.33	7.62	14.90	41.9	47.52	49.48

The second molasses from the fifth run of diffusion, on account of the crowded condition of the sugar-house, could not be kept separate from the mill products. It will be noticed that this molasses was still exceedingly rich in sucrose.

The apparent percentage of sucrose is as high as in the first molasses, but this is due to the much higher content of water in the latter product.

Nevertheless the sugar yield would still be very large to reduce the third molasses to the relative proportions of sucrose and glucose contained in the sample from the Calumet plantation, sent by W. J. Thompson, the analysis of which will follow.

In view of this exceeding richness it would seem that the estimated yield of third sugars from the run given in Bulletin 17, viz, 15 pounds per ton, is entirely too low. This yield would doubtless have been fully 30 pounds per ton.

While the chemical control of the diffusion experiments has proved reasonably satisfactory, yet there remain many points of interest which can only be determined by more extended investigations.

Among these may be mentioned the marked oxidizing power of the bone-black on diffusion juices. These juices on reaching the bone-char-filters were as nearly neutral as possible. On issuing from the filters they were intensely acid, and were again treated with lime before a second filtration. Diffusion juices have proved to be much more amenable to treatment for clarification than our first experiments with diffusion applied to sorghum indicated. A simple treatment of the juice with lime, careful skimming and subsequent precipitation of the sediment in settling tanks, appears to be all that is necessary to make a fine article of raw sugar, either with sorghum or sugar canes.

SUMMARY OF DATA FOR FOUR YEARS AT MAGNOLIA.

BY G. L. SPENCER.

The crop of 1887 was in many respects a remarkable one. In the early spring the cane was considerably larger than in average seasons. The stand was unusually good. Favorable rains and exceptionally good weather permitted a very thorough cultivation. The rows were well shaded before the 1st of July. All these favorable conditions united to make this crop the best in the history of the plantation. Magnolia seemed to be especially favored. When the fields above and on the opposite side of the river were too wet for cultivation those of Magnolia were in the best possible condition.

The following is a brief résumé of the growing seasons of the four years since the establishment of the Magnolia station:

Season of 1884.—The spring weather was favorable and continued so until the 1st of June, then followed a period of wet weather lasting until August, which was a very dry month. September and October were favorable to the ripening of the cane. During the rolling season there were frequent and heavy rains. The tonnage was good, and the quality of the cane excellent.

Season of 1885.—Exceptionally wet weather continued through the early part of this season. The rainfall from April to July was limited to two or three showers. There were frequent rains in August and September. The rest of the season was exceptionally cool and dry. A severe wind storm in September completely prostrated the cane. The wet weather in September and the wind storm damaged the cane very materially. The tonnage was large.

Season of 1886.—In January a freeze of remarkable severity threatened damage to the stubble. Small crops were predicted for the next season. The crop was small, but the shortage was not attributable to the results of the freeze.

February, March, and April were cold and wet; consequently the cane obtained a late start. May was dry and cool; June and July were too wet to permit of proper cultivation; August was dry and exceedingly hot. These adverse conditions all tended to stunt the cane. Although the start was good the tonnage was small. The juice was exceptionally rich and pure.

Season of 1887.—The cane obtained an early start. The weather was favorable throughout the season. The crop was but little damaged by the heavy wind storms in August and October. The tonnage was exceptionally large and the juice excelled in richness and purity.

It may be seen from the above résumé that two of the seasons were very favorable, one of these exceptionally so.

The following table of averages shows the quality of the juices for the four seasons:

Season.	1884.	1885.	1886.	1887.
Degree Brix.....	16.54	15.80	16.20	16.37
Per cent. sucrose.....	13.05	12.11	13.50	13.69
Per cent. glucose.....	67	1.02	.61	.77
Co-efficient of purity.....	78.69	76.64	83.33	83.48

The quality of the cane in 1885 was exceptional. The proportion of glucose is considerably above the average for the four seasons. The percentage of sucrose is low. The analyses for this season show fully thirty pounds less available sugar present than those for 1887.

A comparison of the analyses of juices for the seasons of 1886 and 1887 shows that they were of almost exactly the same average quality, although in the latter season the tonnage was about twice that of 1886. Many planters considered it impossible to obtain a very large tonnage and at the same time a rich cane.

The yield and quality of the cane in 1887 indicate that a large cane does not necessarily carry a weak juice. On the contrary, some of the heaviest cane on Magnolia was the richest, containing about 15.5 per cent. sucrose in the juice. All this cane, including the heaviest, was quite ripe.

WORK AT MAGNOLIA PLANTATION.

*Crop of 1887-'88.**

Tons of cane.....	13,344
Acres plant-cane	275
Acres first year's stubble	242
Acres second year's stubble.....	87
Total	604
Average tonnage per acre	22.09
Total weight, first sugar	pounds.. 1,659,120
Total weight, grained seconds.....	do..... 220,484
Total weight, wagon seconds	do..... 327,269
Total weight, third sugars	do..... 214,178
Total weight, all sugars.....	do..... 2,421,051

*Averages for entire crop, including diffusion work.

Average yield of sugar per ton of cane.....	pounds..	181.43
Per cent. of yield, sugars.....		9.072
Total gallons of molasses.....		58,350
Total pounds of molasses, at 11½ pounds per gallon		671,025
Per cent. of yield of molasses.....		2.514
Per cent. of yield of masse cuite (<i>i. e.</i> , sugar and molasses).....		11.586
Pounds sugar per acre		4,008.3
Pounds molasses per acre.....		1,110

MAGNOLIA PLANTATION.

Crop of 1887-'88.—Diffusion work.*

Tons of cane worked.....		913
First sugar.....	pounds..	121,964
Second sugar, grained.....	do....	31,764
Second sugar wagons.....	do....	15,935
Third sugar wagons.....		14,653
Total sugar		184,316
Average yield, first sugar, per ton.....	pounds..	133.58
Average yield, second sugar grained, per ton.....	do....	34.17
Average yield, second sugar wagons, per ton.....	do....	17.46
Average yield, third sugar wagons, per ton.....	do....	16.05
Total sugar per ton of cane.....		201.26
Per cent. of yield.....		10.063

MAGNOLIA PLANTATION.

Crop 1887-'88.

	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Total.
Tons of cane rolled.....	494	2,261	2,244	2,260	806	3,966	12,431
Extraction, per cent.....	78.60	79.02	79.01	78.48	79	79.30	78.94
Pounds 1st sugar per ton cane.....	101	*132.80	*139.94	*123.50	*122.70	*144.50	*138.83
Pounds 2d sugar per ton cane.....	34	8	38.86	29.60	40.50	41.60	25.05
Pounds 3d sugar per ton cane.....	16.05	16.05	16.05	16.05	16.05	16.05	16.05
Total sugar per ton cane, lbs.....	151.05	156.85	192.85	169.15	179.25	202.15	179.93

* Includes grained seconds.

MAGNOLIA PLANTATION.

Crop of 1887-'88.—Mill work.

Total tons of cane rolled.....		12,431
Pounds of juice.....		19,626,062
Extraction per cent cane.....		78.94
First sugar.....	Pounds..	1,537,156
Second sugar grained.....	do....	188,720
Second sugar wagon.....	do....	311,334
Third sugar wagon.....	do....	199,525
Total sugars.....	do....	2,236,735
Average first sugar per ton cane.....	do....	123.66
Average second sugar grained per ton cane	do....	15.18
Average second sugar wagon per ton cane.....	do....	25.05

* Average of all the cane worked by diffusion.

Average third sugar wagon per ton cane	pounds..	16.05
Average total sugar per ton cane.....	do....	179.93
Per cent. of yield, sugara.....		8.996

SPECIAL ANALYTICAL WORK.

Several problems were presented during the progress of the work at Magnolia for solution. It is difficult to get time during the progress of manufacture to study such special problems; as much time, however, as I could take from the general supervision of the work was given to this special analysis.

COMPARISONS OF DIRECT AND INDIRECT POLARIZATION.

If sorghum and cane juices were composed alone of a solution of sucrose, the quantity of this substance could be determined at once by a direct polarization; unfortunately for the simplicity of chemical manipulation, such is not the case. These juices contain other substances which are optically active. In sorghum juices especially we find large quantities of substances present other than sucrose, which have the power to affect the polarized ray.

In cane juices the substances which tend to produce right-handed rotation are soluble starch, so-called, and its derivatives, dextrine and dextrose.

Of the substances tending to produce left-handed rotation at ordinary temperatures may be mentioned invert sugar and certain nitrogenous bodies.

Were these left-handed and right-handed bodies present in neutralizing proportions they would have no effect upon the polariscopic determinations of the sucrose, but such is not always the case; hence, a direct reading on the polariscope of sugar juices can not always be relied upon to give exact data concerning the proportion of sucrose present.

In the case of juices the variation may not be marked, but after concentration a direct polariscopic reading of the *masse cuite*, or molasses, may prove very erroneous.

To determine the magnitude of this variation in the juices of sirups and molasses from sugar cane, the following analyses were made.

In Table No. 50 are found data relating to clarified juices.

These samples were taken with the greatest care. The measurements were made in tared flasks, with a weighed quantity of the juice, and all of the analytical operations conducted with the greatest precautions. It will be seen by consulting the mean data of the table that the percentage of sucrose was increased from 14.49, the direct reading, to 14.67, the percentage given by the polariscope after inversion. The mean quantity of sucrose is increased by about one-third of the percentage of the reducing sugar present.

TABLE No. 50.—Single and double polarization of mill juices, *Magnolia*.

Number.	Single polarization sucrose.	Invert polarization.	Temperature.	Sucrose by double polarization.	Increase.	Glucose.
	<i>Per cent.</i>		<i>° C.</i>	<i>Per cent.</i>		<i>Per cent.</i>
1	14.7	— 4.84	24.0	14.90	0.20	.....
2	12.75	— 4.30	23.0	12.92	0.17	.....
3	15.53	— 4.75	25.5	15.40	— 0.07	.53
4	13.75	— 4.90	23.0	14.07	0.32	.40
5	13.02	— 4.43	21.5	13.09	0.07	.36
6	13.95	— 4.35	27.0	14.02	0.07	.47
7	16.45	— 5.23	29.0	16.74	0.29	.42
8	15.58	— 4.57	31.0	15.84	0.26	.53
9	16.23	— 4.98	31.25	16.52	0.29	.56
10	16.18	— 4.90	27.0	15.40	0.22	.57
11	14.80	— 4.68	28.0	14.99	0.19	.64
12	12.73	— 4.18	.....	12.84	0.11	.56
13	13.65	— 4.95	.....	13.93	.....	.....
Averages	14.49	.....	.....	14.67	.19	.50

In Table No. 51 is given the single and double polarization of sirups derived from the juices in Table No. 50.

The same precautions were taken in the selection of samples and in the analytical manipulation as in the preceding table.

The increase in the percentage of sugar on double polarization in the case of the sirups is equivalent to about one-half of the percentage of glucose present. It will be noticed in Table No. 50 that there are numerous examples of a like proportionate increase. In sample No. 3, in Table No. 50, there is an actual loss of sucrose, the second reading being .07 less than the first. This result was doubtless due to some error which all the precautions taken could not avoid.

TABLE No. 51.—Single and double polarization of sirups from mill juices.

Number.	Single polarization.	Double polarization.	Temperature.	Sucrose.	Increase.	Glucose.
	<i>Per cent.</i>	<i>°</i>	<i>° C.</i>	<i>Per cent.</i>		<i>Per cent.</i>
2	44.04	— 17.49	26.0	45.07	1.03	.....
4	45.25	— 16.23	23.0	46.40	1.15	1.39
5	41.50	— 15.43	19.0	42.27	0.77	1.19
6	43.00	— 14.28	26.5	43.81	0.81	1.44
7	46.88	— 14.68	28.5	47.37	0.49	1.28
8	45.53	— 14.74	29.5	46.63	1.10	1.63
9	42.15	— 13.28	31.25	43.19	1.04	1.51
10	44.85	— 14.80	26.5	45.62	0.77	1.76
11	42.85	— 13.31	27.0	43.04	0.19	1.92
12	39.98	— 13.26	25.25	40.53	0.55	1.81
Averages	43.60	.....	.....	44.39	.79	1.55

In Table No. 52 are found the data of polarizations of various samples of molasses taken at different times during the season. Unfortunately, in only three cases was the percentage of glucose determined. In these cases the increase on double polarization is equal to almost half the percentage of glucose present. The mean increase, however, viz, 8.30 per cent., would probably not have been much greater than one-third of the mean percentage of glucose present in the molasses.

TABLE NO. 52.—*Differences between single and double polarizations of molasses.*

Number.	Single polarization.	Polarization after inversion.	Temperature.	Sucrose.	Increase.	Glucose.
	<i>Per cent. sucrose.</i>		<i>° C.</i>	<i>Per cent.</i>		<i>Per cent.</i>
1	46.0	— 24.2	20.	52.4	6.4	-----
2	45.5	— 23.1	20.	51.2	5.7	-----
3	25.1	— 24.1	20.	36.7	11.6	25.25
4	43.8	— 20.4	23.5	51.6	5.8	-----
5	28.2	— 23.7	22.5	39.04	10.84	-----
6	27.1	— 23.54	21.0	37.0	10.8	23.90
7	36.9	— 23.32	22.0	45.3	8.4	16.60
8	38.0	— 22.33	24.0	45.7	7.7	-----
9	35.7	— 21.78	21.0	43.1	7.5	-----
Averages	36.48	-----	-----	44.77	8.30	-----

Description of samples.—No. 1, sample of first molasses; No. 2, sample of first molasses; No. 3, sample of third molasses; No. 4, sample of first molasses; No. 5, sample of third molasses; No. 6, sample of third molasses; No. 7, sample of second molasses; No. 8, sample of second molasses; No. 9, sample of second molasses.

In Table No. 53 are found the analyses of some samples of molasses sent by Mr. W. J. Thompson, of Calumet plantation. In these samples we have again the remarkable illustration of the error into which the analyst would fall who would rely upon a single polarization alone. As a check upon the results the sucrose was determined also with an alkaline copper solution. The percentage obtained in this way agrees remarkably well with that got by double polarization.

In these cases the total increase is a little less than one-third of the amount of glucose present.

TABLE NO. 53.—*Composition of third molasses.*

[Furnished by W. J. Thompson, Calumet plantation, Patterson, La.]

No.	Serial number.	Moisture.	Ash.	Sucrose direct.	Sucrose indirect.	Sucrose by copper.	Albuminoids.	Glucose.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	5018	23.09	7.55	15.85	25.34	26.00	1.97	29.20
2	5019	26.15	9.35	17.45	26.02	26.14	2.40	28.08
3	5020	25.30	7.84	17.15	25.93	26.19	2.49	30.07
4	5021	26.09	7.01	17.05	25.46	25.59	2.30	31.31

TABLE NO. 53 (bis).—*Composition of third molasses, average sample from Magnolia plantation.*

No.	Moisture.	Ash.	Sucrose direct.	Sucrose indirect.	Sucrose by copper.	Albuminoids.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
5058	30.37	9.54	20.73	27.65	27.78	1.92	21.12

Aside from the larger quantity of water in the third molasses from Magnolia, the chief difference between the Calumet and Magnolia

samples is found in the smaller percentage of reducing sugar in the latter.

These results with the sugar-cane juices show that when single polarization alone is practiced the real percentage of sucrose can be approximately obtained by adding to the direct reading one-third of the percentage of glucose present.

The results also show the preponderance of lævo-gyratory impurities in cane juices.

The left-handed disturbance, however, is greater than would be expected from the amount of invert sugar present.

We would, therefore, conclude that the albuminous matters present are also active, or that in the reducing sugar naturally contained in the juice there is a preponderance of lævulose.

In sorghum juices I have shown in a previous publication that the differences between direct and double polarization are not so great. This is due to the fact that in sorghum there is a large portion of so-called soluble starch and dextro-gyratory bodies.

STUDY OF INVERSION IN THE YARYAN QUADRUPLÉ EFFECT.

To determine the invertive effect of concentrating the juices in the Yaryan quadruple effect pan, a series of careful analyses of entering juices and issuing sirups was made. The samples were taken in the following way, viz: From the feed-box of the Yaryan apparatus a measured sample of the juices was taken every two minutes for thirty minutes; four minutes after taking the first sample of juice and every two minutes thereafter for thirty minutes a measured sample of the issuing sirup was taken. After mixing the samples of juice and sirup were subjected to analysis. It will be seen that by the above method the samples of juice and of sirup were strictly comparable. In each case the sample for analysis was weighed out and made up to a standard volume in a tared flask. The analytical manipulations were conducted with every possible precaution.

The results of the work are given in Tables Nos. 54 and 55.

TABLE NO. 54.—*Test for inversion in Yaryan pan.—Clarified juicoc.*

No.	Date.	Total solids.	Purity on direct polarization.	Purity on indirect polarization.	Sucrose direct polarization.	Sucrose indirect polarization.	Reducing sugars.	Reducing sugars to 100 of sucrose direct polarization.	Reducing sugars to 100 sucrose indirect polarization.
	1887-'88	<i>Per cent.</i>			<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>		
1	Dec. 28	15.93	88.32	88.32	13.75	14.07	.40	2.91	2.84
2	Dec. 28	14.53	89.61	90.09	13.02	13.09	.36	2.75	2.75
3	Jan. 4	15.88	87.85	88.29	13.95	14.02	.47	3.47	3.35
4	Jan. 5	17.88	92.00	93.62	16.45	16.74	.42	2.55	2.51
5	Jan. 6	17.17	90.73	92.26	15.58	15.84	.53	3.40	3.36
6	Jan. 7	17.93	90.52	92.14	16.23	16.52	.56	3.45	3.39
7	Jan. 8	16.71	90.85	91.55	15.18	15.40	.57	3.75	3.70
8	Jan. 9	16.78	88.20	89.33	14.80	14.99	.64	4.33	4.27
9	Jan. 10	14.18	89.77	90.55	12.73	12.84	.56	4.41	4.37
Averages.		16.83	89.54	90.68	14.63	14.83	.50	3.45	3.39

TABLE NO. 55.—*Sirups.*

[Dates and numbers correspond to comparative samples in above table.]

1	Dec. 28	51.23	88.33	90.60	45.25	46.40	1.39	3.07	3.00
2	Dec. 28	46.70	88.87	90.51	41.50	43.27	1.19	2.87	2.82
3	Jan. 4	49.02	87.72	89.35	43.00	43.81	1.44	3.35	3.28
4	Jan. 5	50.54	92.76	93.73	46.88	47.37	1.28	2.73	2.70
5	Jan. 6	51.16	88.99	91.14	45.53	46.63	1.63	3.59	3.50
6	Jan. 7	47.60	88.55	90.74	42.15	43.19	1.51	3.57	3.50
7	Jan. 8				44.85	45.62	1.76	3.92	3.86
8	Jan. 9	48.83	87.76	88.15	42.85	43.04	1.92	4.48	4.46
9	Jan. 10	45.22	88.41	89.63	39.98	40.53	1.81	4.53	4.47
Averages		48.79	88.92	90.48	43.55	44.32	1.55	3.57	3.51

Any inversion which would take place in the process of concentration would be indicated by an increase in the ratio of reducing sugar and sucrose.

In the entering juices the mean ratios are as follows, viz :

By direct polarization, 3.45 parts reducing sugar to 100 of sucrose.

By double polarization, 3.39 parts reducing sugar to 100 of sucrose.

For the issuing sirups the ratios are as follows :

By direct polarization, 3.57 parts reducing sugar to 100 of sucrose.

By double polarization, 3.51 parts reducing sugar to 100 of sucrose.

It will be seen by the above numbers that the inverting effect of the Yaryan pan is practically nothing. It amounts to only one-tenth of a pound to 100 pounds of sugar made or 2 pounds to the ton of sugar.

ANALYSES OF BAGASSE.

Sixteen determinations were made at various times during the season of the quantity of water and sugar in the bagasse. The samples were taken as follows: From time to time during fifteen to twenty minutes a handful of the bagasse issuing from the mill was taken and placed in a covered vessel. These samples were then thoroughly mixed together and a portion taken for analysis. Small quantities of bagasse were taken from the selected portion and cut into very fine chips. Weighed portions of these chips were then dried at 105° C., and weighed for the determination of moisture.

For the determination of sucrose, weighed portions of the bagasse were extracted in a marked stoppered bottle for two hours at the temperature of boiling water. After cooling, the contents of the bottle were poured in a mortar and thoroughly rubbed up with a pestle. The sucrose was determined in a filtered portion of the liquid, due allowance being made for the volume occupied by the fiber of the cane. The results of the analyses are given in Table No. 56.

TABLE NO. 56.—Composition of bagasse.

No.	Date.	Water.	Sucrose.	No.	Date.	Water.	Sucrose.
	1888.	<i>Per cent.</i>	<i>Per cent.</i>		1888.	<i>Per cent.</i>	<i>Per cent.</i>
1	Jan. 4	52.60	8.58	10	Jan. 8	54.99	7.50
2	Jan. 4	52.87	7.69	11	Jan. 9	55.08	7.95
3	Jan. 5	52.99	8.10	12	Jan. 9	54.09	7.65
4	Jan. 5	53.89	8.19	13	Jan. 10	53.59	7.44
5	Jan. 6	52.51	7.73	14	Jan. 10	55.58	6.88
6	Jan. 6	51.69	8.00	15	Jan. 11	56.71	7.74
7	Jan. 7	53.12	8.07	16	Jan. 11	56.78	7.96
8	Jan. 7	52.02	7.95	Averages.....			
9	Jan. 8	53.97	7.35			54.00	7.79

It will be seen that the mean percentage of the water in the bagasse was 54 and the sucrose 7.79. It appears from the above analyses that the bagasse contains water other than that in the sugar juice of the cane. This fact is also shown by the following phenomenon.

If a sugar-cane be passed through a small mill, the top entering the mill first, drops of water will be seen to issue from the butt of the cane as it approaches the rolls; if this water be tasted it will be found to be free from sugar. It appears, then, from the analyses of the bagasse and the phenomenon just related that the sap in the circulatory organs of the cane is entirely different from the sugar juices stored in its cells.

ESTIMATION OF TOTAL SOLIDS BY HYDROMETERS AND BY ACTUAL WEIGHT.

Attention has already been called in this bulletin to the error which may arise from estimating the total solids in sugar juices and sirups from the specific gravity as determined by a hydrometer.

In Table No. 57 is given a comparison of the results obtained in estimating the total solids in cane juices by careful drying in a flat dish partly filled with sand. The method of procedure was as follows:

A flat platinum dish was filled about two-thirds full of pure dry sand and weighed; from a weighing bottle about 2 grams of the cane juice was placed on the sand, and the exact amount taken obtained by re-weighing the weighing bottle.

The dish was now dried at 100° until the moisture was nearly all driven off, and then for a half an hour at 105°. In each case the amount of total solids as given by the Brix saccharometer was greater than that obtained by actual drying. The mean increase was .56 per cent.

TABLE 57.—Comparison of total solids by spindle and drying on sand.
JUICES.

No.	Date.	By drying.	By spindle.	Increase.	No.	Date.	By drying.	By spindle.	Increase.
	1888.	<i>Per ct.</i>	<i>Per cent.</i>			1888.	<i>Per ct.</i>	<i>Per cent.</i>	
1	Jan. 4	15.08	16.07	.89	8	Jan. 8	16.70	17.23	.47
2	Jan. 5	17.87	18.64	.77	9	Jan. 9	16.53	17.17	.64
3	Jan. 6	16.81	16.93	.12	10	Jan. 9	16.75	17.30	.53
4	Jan. 6	17.17	17.80	.63	11	Jan. 10	15.87	16.68	.79
5	Jan. 7	16.57	16.06	.39	12	Jan. 10	14.18	14.85	.67
6	Jan. 7	17.93	14.54	.61	Averages.....				
7	Jan. 8	16.71	17.46	.75			16.57	17.13	.56

TABLE 58.—*Sirups.*

1	Jan. 4	48.54	49.03	.48	5	Jan. 9	48.83	50.22	1.39
2	Jan. 5	50.51	52.72	2.18	6	Jan. 10	45.22	48.76	1.54
3	Jan. 6	50.85	51.83	.97					
4	Jan. 7	47.60	48.64	1.04		Average	48.60	49.86	1.27

In Table 58 the same comparison is made with sirups. In order that the sirups might not occlude moisture a less quantity was taken than of the juices, so that the total solid residue might be the same. The mean increase in the case of sirups as determined by the Brix spindle was 1.27 per cent. With sugars and molasses enough alcohol must be added to the dish containing the sand and samples to dissolve the latter thoroughly and distribute them evenly through all parts of the sand. Not being quite satisfied with the result obtained by the method given above, I tried the device of using paper coils for the absorption of the juices whose total solids were to be determined.

The manipulation was as follows: A piece of thick filtering paper 40 centimeters in length and 5 to 8 centimeters wide was rolled into a coil and tried at 105°. While still hot it was placed in a dried weighing tube and carefully stoppered. When cold it was weighed together with the tube.

About 2.5 grams of the juice is now placed in a small beaker covered with a watch glass and weighed. One end of the coil is dipped into the beaker and held there until the juice is absorbed. By means of the dry end, the coil is transferred to the air bath, placed in an upright position with the wet end up and dried for two hours at 100°. While still hot it is again placed in the weighing tube, and, when cold, weighed.

By reweighing the beaker and the cover the weight of juice taken is accurately determined. The increase of weight of the coil gives the total quantity of solid matter present in the weight of juice taken. This method was introduced so late in the season that only a few trials of it were made, but they were eminently satisfactory. The results are given in Table No. 59:

TABLE NO. 59—*Total solids by drying on paper coils.*

MILL JUICES.

No.	Date.	Total solids.	Total solids by spindle.	Total solids by sand.
	1888.	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	Jan. 11	16.22	16.53	16.05
2	Jan. 12	15.80	16.70	16.16
3	Jan. 13	15.94	16.87	.....
4	Jan. 17	15.42	16.07	.....
Average	.....	15.85	16.54	.....

TABLE No. 59—*Total solids by drying on paper coils—Continued.*

DIFFUSION JUICES.

1	Jan. 16	10.10	11.37	.....
2	Jan. 17	9.80	10.87	.....
3	Jan. 17	9.57	10.47	.....
Averages	.....	9.82	10.84	.....

As in the case of drying in sand, the amount of solid matter found in juice is uniformly less than was indicated from the reading of the spindle.

EFFECT OF TREATMENT OF MOLASSES WITH SUPERPHOSPHATE OF LIME AND ALUMINA.

It is the custom in the sugar-houses of Louisiana to dilute the molasses and treat it with superphosphate of lime and alumina, or other chemicals, before reboiling it for sugar. To determine the effect which this treatment had upon the molasses, the analyses which are recorded in Table No. 60 were made.

TABLE No. 60.—*Treatment of molasses with superphosphate of lime and alumina.*

MOLASSES BEFORE TREATMENT.

No.	Total solids.	Purity, direct polarization.	Purity, indirect polarization.	Sucrose, direct polarization.	Sucrose, indirect polarization.	Glucose.	Glucose per 100 sucrose.	Glucose per 100 sucrose, indirect.
1	<i>Pr. ct.</i> 65.59	71.30	77.50	<i>Per cent.</i> 46.75	<i>Per cent.</i> 50.80	<i>Per cent.</i> 6.33	<i>Per cent.</i> 13.55	<i>Per cent.</i> 12.47
2	61.72	71.29	76.17	44.00	47.01	5.71	12.96	12.16

MOLASSES AFTER TREATMENT.

1	63.86	72.70	76.80	46.30	48.91	6.17	13.33	12.64
2	60.45	72.01	75.89	43.53	45.88	5.43	12.43	11.64

REMOVED SKIMMINGS.

1	67.03	77.20	78.90	51.70	53.90	6.71	12.97	12.68
2	64.69	75.36	79.15	48.75	51.20	6.17	12.65	12.03

The table is divided into three parts, the first being the analysis of the molasses before treatment; second, analysis after treatment; and third, the analysis of the removed skimmings.

In the three cases the numbers refer to the same sample. It is quite difficult to secure the same density in each case, and comparison should be made with the ratio of the reducing sugar to the sucrose. From this it is seen that the skimmings, which were removed and which were supposed to be gum, were nothing but air-bubbles, surrounded with a film

of molasses. It is difficult to see any beneficial result attending the treatment in question.

EFFECT OF DIFFERENT METHODS OF CLARIFICATION.

In order to determine the amount of organic matter removed by different methods of clarification the following experiments were made: Weighed samples of mill juice were treated with subacetate of lead until no further precipitation took place. The precipitate was then thoroughly washed with hot water until all excess of lead was removed and then dried.

Similar treatment was given to the same juice after clarification by lime in the usual way, after filtration through lignite, and after single carbonatation. The results are recorded in Table No. 61.

TABLE NO. 61.—*Effects of different methods of clarification.*

	Raw.	Clarified.	Lignite.	Carbonated.
Weight of lead precipitate:				
December 20, 1887, grammes.	2.1919	1.9452	1.7685	1.2725
December 21, 1887.....	2.2964	2.1515	2.1930	1.7058
Per cent of lead:				
December 20, 1887.....	62.08	52.43	69.53	71.68
December 21, 1887.....	66.01	60.31	71.68	71.52
Sucrose, per cent:				
December 20, 1887.....	13.08	13.45	15.12	13.99
December 21, 1887.....	13.78	14.01	15.02	14.74
Albuminoids, per cent:				
December 20, 1887.....	.07	.07	.03	.06
December 21, 1887.....	.11	.07	.03	.03
Purity:				
December 20, 1887.....	81.75	82.50	84.38	85.67
December 21, 1887.....	85.34	86.32	84.71	88.58

It is seen that the weight of the dried precipitate is in every case greatest in the raw juice and least in that which had been subjected to single carbonatation. The purity of the juice was increased least by ordinary clarification, next by filtration through lignite, and most of all by carbonatation.

In regard to the removal of albumen, filtration through lignite appears to be the most efficacious method.

Carbonic dioxide gas in gases from lime-kiln and bagasse chimney.

The quantity of carbonic acid in the gases from the lime-kiln and bagasse chimney is given in Table No. 60.

The object of determining the percentage of CO₂ in the bagasse smoke was to see if it could be used in the process of carbonatation. Since, with cane juices, this process requires so little lime it seems probable that the gases from the Bagasse chimney can be used for this purpose.

TABLE NO. 60.—Carbonic acid gas from furnace.

Date.	Hour.	Num-ber.	CO ₂ .
			<i>Per cent.</i>
November 27	11 a. m. .	1	12.5
Do	12 m. .	2	13.88
Do	1 p. m. .	3	15.89
Do	3 p. m. .	4	18.54
Do	5 p. m. .	5	21.47
Do	8 p. m. .	6	23.93
November 28	9 a. m. .	7	21.60
Do	4 p. m. .	8	20.80
Do	9 p. m. .	9	20.54
November 29	6 a. m. .	10	12.33
Do	3 p. m. .	11	12.39
Do	9 p. m. .	12	10.02
November 30	7 a. m. .	13	15.61
December 1	10 a. m. .	14	22.04
Do	5 p. m. .	15	28.60
December 3	9 a. m. .	19	11.25
December 9	4 p. m. .	20	25.92
December 10	5 a. m. .	21	33.50
Do	10 a. m. .	22	25.42
December 11	2 a. m. .	23	29.89
Do	11 a. m. .	24	17.88

Carbonic acid gas from Bagasse chimney.

December 2	9 a. m. .	16	11.44
Do	11 a. m. .	17	11.15
Do	3 p. m. .	18	8.8

DATA RELATING TO SORGHUM AS A SUGAR-PRODUCING PLANT.

The problem of the possible profitable production of sugar from sorghum has occupied the attention of chemists, agronomists, and manufacturers for many years.

I will not insist here on the immense advantages which would accrue to American agriculture by the development of an indigenous sugar industry. There is no true friend of our farming interests who does not wish our sugar to be produced at home, and if sorghum can help to the consummation of such a wish we ought to know it.

A full discussion of these aspects of the subject can be found in my presidential address before the Washington Chemical Society, delivered on the 9th of December, 1886.¹

It seems to me that we have now reached a point in the study of the problem of the production of sugar from sorghum where it is possible, by a careful review of the ground already passed over, to secure an accurate notion of the progress which has been made.

It is to this task that I have devoted the present study. For convenience the study of the problems may be divided into three parts, viz: (1) Chemical, (2) experimental, (3) practical.

CHEMICAL.

The amount of analytical work which has been done on sorghum in this country is enormous. At most I can give only a summary of the recorded results.

This analytical work may be best studied by dividing it into two groups, namely: (a) Work done by the Department of Agriculture and (b) other work.

(a) WORK DONE BY THE DEPARTMENT OF AGRICULTURE.

The first analyses of sorghum canes by the Department of Agriculture were made by Dr. C. M. Wetherill in 1862.

¹ Second Ann. Bulletin Washington Chemical Society, pp. 11 *et seq.*

A mean of seventeen analyses of imphee and sorghum showed the following results:¹

	Sorghum.	Imphee.	
		First mean.	Second mean.
Sucrose.....	Per cent. 4.29	Per ct. 4.13	Per ct. 6.19
Glucose.....	6.08	7.00	3.65
Total sugars.....	10.37	11.13	9.84

Dr. Wetherill also gives a table of mean results obtained by others (p. 533), and adds the following observations:

It follows, from the experiments thus quoted and reported, that the largest proportion of cane sugar to uncrystallizable sugar is afforded by the juice analyzed by Lawrence Smith, to wit, as 10 to 2. My average results fall far below this; yet if the analyses of my best canes are taken, their juice will compare favorably with that of the analysis of Smith. For example, by the analyses numbered 8, 10, 11, for every 10 parts of cane sugar found we have, respectively, 2.1, 1.8, and 1.8 per cent. of uncrystallizable sugar. It is remarkable that in analyses 10 and 11 the juices differing so much in actual saccharine richness should contain the same relative proportion of cane sugar to uncrystallizable sugar. When my mean results are compared with the results afforded by the practical experiment of Mr. Lovering, who grew the sorghum, analyzed its juice, and converted the same into cane sugar and molasses, it appears that my mean of sorghum analyses gives very nearly the same proportion of cane sugar to uncrystallizable sugar, and that my imphee mean gives a larger proportion of cane sugar. I think that my analyses and their means will give a moderately accurate reflection of the present state of the sorghum and imphee culture in our country.

There are, doubtless, finer canes grown than I have examined, and richer both in sirup-making quality and in the proportion of cane sugar present; but the analyses probably represent the present condition of the cane as planted.

Henri Erni² reports one analysis of sorghum. It gave:

	Per cent.
Sucrose	10.31
Glucose	2.07

He adds:

Contrary to my expectations, I found that the expressed sorgho juice of ripe cane whether neutralized by lime or not, refused to crystallize, for what solidified or granulated after long standing of the sirup was grape-sugar. This fact has been established by the largest and most skillful farmers and experimenters, and admitted at the western sorghum conventions. The result might be ascribed to the total inversion previously of the cane-sugar by the influence of acid, or of a ferment, but this is not the case, as I have repeatedly been able to prove. The following extreme case may suffice for illustration of this fact: In the sugar determination which is here given, cane-sugar was found, and yet the most persistent efforts failed to produce a single crystal in the concentrated liquid.

¹ Department of Agriculture, report, 1862, pp. 514 *et seq.*

² Agricultural Report, 1865, p. 48.

Dr. Thomas Antisell¹ reports analyses of frozen and fresh canes. The juice from frozen canes had the following composition:

	Per cent.
Sucrose	11.10
Glucose	8.90

The juice of the fresh canes had the following composition:

	Per cent.
No. 1. Sucrose	7.86
Glucose	4.38
No. 2. Sucrose	5.94
Glucose	3.60

Dr. Antisell adds the following observations:

Contrasting the amount of sugar in the fresh and dry cane, the latter greatly preponderates; and were the question only on the amount of sugar to be obtained, the decision would be in favor of working on the partially dried canes; but on observing the ratio of glucose and cane sugar in the fresh juice and that expressed later, it will be remarked that the relative amount of glucose is much higher, so that the sugar appears to be gradually passing into glucose the longer it remains in the cane, showing that the fermenting causes are as active within the stem of the drying cane as after the juice has been expressed and exposed to the air. Several attempts were made in the laboratory to granulate the sugar of this juice; but whether neutralized and defecated or not, the invariable result was the disappearance of cane sugar, and a uniform sirup of uncrystallizable sugar. Thus far, then, laboratory examinations indicate the necessity of evaporating the juice of the recently cut canes, if it is desired to obtain any crystallizable sugar.

In 1878 Dr. Collier began his extensive studies of sorghum. Dr. Collier gave the following result of the analyses made by the Department of Agriculture in 1879²:

Early amber, from August 13 to October 29, inclusive, fifteen analyses, extending over seventy-eight days, 14.6 per cent. sucrose.

White Liberian, from August 13 to October 29, inclusive, thirteen analyses, extending over seventy-eight days, 13.8 per cent. sucrose.

Liberian, from September 13 to October 29, inclusive, seven analyses, extending over forty-six days, 13.8 per cent. sucrose.

Honduras, from October 14 to October 29, inclusive, three analyses, extending over sixteen days, 14.6 per cent. sucrose.

In 1880 these analyses were continued in large numbers on samples of cane grown in the Department grounds and on others sent in from various localities. The details of these analyses are to be found in the Annual Report of the Department of Agriculture for 1880, pp. 37 *et seq.*

The canes, according to development, were divided into nineteen classes. With the seventh stage, the seed is just entering the milky state. Since a large part of the seed will still be in this state, when the

¹ Department of Agriculture, report, 1866, p. 43.

² Sorghum., p. 186.

manufacture is to be carried on on a large scale, I give the means of the analyses of the different varieties from that stage on¹:

Stages.	Glucose.	Sucrose.	Available sucrose.	Number juices analyzed.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	
7.....	3.80	7.38	4.06*	70
8.....	3.83	7.69	4.26	111
9.....	3.19	8.95	5.50	266
10.....	2.60	9.98	6.60	217
11.....	2.35	10.66	7.22	166
12.....	2.07	11.18	7.77	170
13.....	2.03	11.40	8.00	183
14.....	1.88	11.76	8.33	191
15.....	1.81	11.69	8.21	217
16.....	1.64	12.40	8.86	339
17.....	1.56	12.73	9.73	197
18.....	1.85	11.92	8.27	191
19.....	3.09	12.08	7.82	30
Mean	2.44	10.83	7.28	181

* The method of determining available sugar does not clearly appear.

These analyses were continued in great detail during the following years, 1881 and 1882, and the results are found in the reports of the Department.²

The averages for the whole number of samples for each stage after the sixth is given below.³

Stages.	Glucose.	Sucrose.	Available sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
7.....	3.69	6.08	0.00
8.....	3.70	7.47	1.14
9.....	3.30	8.76	2.86
10.....	2.96	10.00	4.14
11.....	2.74	12.01	6.34
12.....	2.47	13.06	7.01
13.....	2.21	13.98	8.87
14.....	2.23	14.34	9.24
15.....	1.84	15.99	11.14
16.....	1.72	15.94	11.02
17.....	1.83	16.61	11.77
18.....	1.75	15.23	9.83
After 18th	1.73	11.89	6.33
Mean	2.47	12.41	6.55

The effect of frost on the character of the juice was also investigated.⁴ The frost produced a loss of sucrose amounting to 15.5 per cent., and a gain of glucose, 29.1 per cent.

Dr. Collier makes the following observations on the results of the analyses:⁵

GENERAL RESULTS OF ANALYSES BEARING UPON THE QUESTION OF AVAILABLE SUGAR.

By reference to the table giving the general results of all the analyses of the several varieties of sorghum in 1879, 1880, and 1881, the aggregate number of analyses being

¹ Department of Agriculture, Report 1880, pp. 110, 111.

² Department of Agriculture, Report 1881-1882, p. 370 *et seq.*, and Investigations of Sorghum as a Sugar-Producing Plant, special report, 1883.

³ Department of Agriculture, Report 1881 and 1882, pp. 438 *et seq.*

⁴ Department of Agriculture, Report 1881 and 1882, p. 460.

⁵ *Op. cit.*, p. 462.

4,042, and the varieties analyzed being about forty, these results having been obtained from as many distinct varieties by so large a number of separate analyses made in successive years, the general conclusion reached appears established beyond question.

It will be seen that during the early stages of development of these plants, up to and including the sixth stage, the available sugar is given as a minus quantity, i. e., the amount of sucrose in the juice is less than the sum of the glucose and other solids. It will also be seen that in the seventh stage the available sugar is practically none, being only .13 per cent., and this stage represents the period when the seed is in the milky stage. It is then obviously absurd to expect to obtain any sugar by working up the crop until it has advanced beyond this condition toward maturity.

It will also be observed in the table that during these early stages the amount of this minus available sugar remains nearly the same, the average for the first five stages being 3.22 per cent., and also that the available sugar after it first appears rapidly increases in quantity, and remains practically constant through the several subsequent stages; and in this it agrees, as will be seen, with the development of the sucrose, which at a certain period is very rapid, and afterward nearly constant through the season, while, as has been remarked, the sum of the glucose and solids is nearly the same throughout.

EFFECT OF SUCKERS ON COMPOSITION OF JUICE.

The injurious effect of suckers on the juice is shown by the following average analyses of thirty-four varieties.¹

	Suck- ered.	Unuck- ered.	Ratio.
	<i>Pr. ct.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose	13.17	10.55	100: 80.1
Glucose	2.14	2.95	100: 137.9
Solids	3.10	3.58	100: 115.5
Available sugar	8.08	4.49	100: 55.6

ANALYSES OF JUICES FROM SMALL MILLS.²

These analyses were made from September 12 to October 22, 1881. The canes were taken from the experimental plots in the Department grounds and from some other localities in the vicinity of Washington.

The mean results are as follows:

	Per cent.
Sucrose	9.89
Glucose	3.85
Available sugar	3.09

ANALYSES OF JUICES FROM LARGE MILL.³

The analyses were made from September 27 to October 27, 1881. The total quantity of cane ground was 229 tons 444 pounds.

The mean composition of the juice for this entire season was as follows:

	Per cent.
Sucrose	6.94
Glucose	6.38
Not sugars	1.90

¹ *Op. cit.*, p. 465.

² Department of Agriculture, Report 1881 and 1882, pp. 478 *et seq.*

³ Department of Agriculture Report, 1881 and 1882, pp. 506, 507.

In respect of the character of the cane, Dr. Collier makes the following reports:¹

THE WORK OF THE LARGE SUGAR MILL.

Mention has already been made of the several plots of sorghum of different varieties upon the lands of Mr. Patterson, Mr. Golden, and Dr. Dean, which were intended for working upon a scale of sufficient magnitude to afford a practical demonstration of the economical production of sugar upon a commercial scale.

Owing to the backward spring and the ravages of wire and cut worms, two successive plantings of seed almost entirely failed, and it was only after thoroughly coating the seed with coal-tar that a final stand of cane was secured. This third planting was concluded June 18, fully seven weeks after the planting of the plot upon the Department grounds, the examination and working of which has already been discussed in the preceding pages. To any one who has carefully perused this report thus far, or either of the reports of the preceding years, giving the results of our examination of sorghum, it is entirely useless to say that this delay was fatal to success in the production of sugar, and that failure was inevitable unless all our previous experience was to be falsified.

The failure of the crop to mature, as had been confidently predicted during the summer, was fully realized, and at last, with the assurance that the frosts would soon render the crop unfit even for sirup, owing to its immature state, it was resolved to begin work, since, with the limited capacity of the mill, it would require at least two months to work up the entire crop of 135 acres. Accordingly the work of cutting the cane began September 19, and grinding began September 26, and was continued without any serious interruption until October 28. At this time the cane still remaining upon the field, through the effect of frosts and succeeding warm weather, had become worthless, and the cane from only 93½ acres in all was brought to the mill, the last portions of which had already become sour and offensive.

ANALYSES IN 1882.²

Beginning with the stage when the seed was in the milk, I give below the mean results of Dr. Collier's analyses of many different varieties of sorghum in 1882:

	Glucose.	Sucrose.	Available sugar.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Seed in milk.....	2.90	8.45	3.20
Seed in dough.....	2.171	9.88	5.054
Seed hard.....	1.83	10.48	6.233
Sucker seed in milk...	1.203	11.448	7.426
Sucker seed in dough...	1.12	12.25	8.19
Sucker seed hard.....	1.45	12.63	8.56

¹ *Op. cit.*, p. 504.

² *Sorghum as a Sugar-producing Plant*, by Peter Collier, Special Report, 1883, p. 17.

COMPOSITION OF JUICE IN BLADES AND STALKS.

Numerous analyses were made¹ to determine the relative composition of stalk and leaf juice. This comparison will be sufficiently indicated by some of the analyses quoted below :

Stalks.				Leaves.		
No.	Sucrose.	Glucose.	Not sugar.	Sucrose.	Glucose.	Not sugar.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	10.29	3.21	1.84	2.84	1.66	7.83
2	14.64	1.87	1.54	2.15	1.53	9.21
3	11.79	1.15	3.03	4.23	2.25	6.76
4	13.31	.93	3.28	2.23	2.50	7.71

Dr. Collier adds the following observation:²

It is to be observed that in no case was there any available sugar in the juice from the leaves, owing not to the excess of glucose, but to the much larger percentage of solids not sugars in the leaf juice.

FURTHER ANALYSES OF FROSTED CANES.³

	<i>Per cent.</i>
Analyses before frost, November 3, 1882.—Means :	
Sucrose	12.44
Glucose	1.23
Not sugar.....	2.68
Available sugar	8.62
Juice extracted.....	52.19
Analyses after thirteen frosts, December 8.—Means :	
Sucrose	14.35
Glucose.....	2.85
Not sugar.....	2.98
Juice extracted.....	39.17
Loss of juice.....	32.69
Gain in sucrose.....	15.35
Gain in glucose	131.71
Loss in available sugar.....	1.16

ANALYSES DURING THE YEAR 1883.

Numerous analyses were made by the Division of Chemistry of the Department of Agriculture during the season of 1883, under my supervision.

Considering that it had been sufficiently well established by the researches of Dr. Collier, that small plats of cane under careful culture and proper fertilization afforded an extremely rich saccharine plant, I directed attention chiefly to the character of the juice as a whole. The analyses represent the average composition of the juice from 746,350 pounds of cane.¹

¹ *Op. cit.*, pp. 29-30.

² *Op. cit.*, p. 30.

³ *Op. cit.*, p. 34.

⁴ Bull. No. 3, pp. 43 and 47.

Means :

	Per cent.
Sucrose	8.38
Glucose	4.09
Total solids	14.06

The part of the cane ground from September 29 to October 4 was of an exceptionally poor quality. Its analysis is given separately.¹

	Per cent.
Sucrose	6.73
Glucose	6.16
Purity co-efficient	50.00

A separate study of the mill juices was also made from October 16 to November 21.²

Following are the means of these analyses :

	Per cent.
Sucrose	9.04
Glucose	4.08
Total solids	14.81

Analyses of diffusion juices obtained from the same lot of cane and at the same time showed the following composition :³

	Per cent.
Sucrose	4.95
Glucose	2.42
Total solids	8.02

Analyses were also made of canes grown in Indiana.

The canes were cut and prepared as follows :⁴

These canes were cut, the leaves and tops left undisturbed, the cut surface covered with melted wax, and the whole wrapped carefully in paper and sent by express to the laboratory here for analysis.

Nos. 1 and 2 were cut in the afternoon of October 1 and analyzed October 4, having been three days on the road.

No. 1 was a sample of eight selected canes. No. 2 was a sample of sixteen canes taken seriatim from an average row, and represents the cane as a whole. It seems to have deteriorated very little in transit, and the analyses of the sirup go to show that the average of the whole patch was about a mean of the results of Nos. 1 and 2. No. 3 was cut at 4 p. m. October 1 and analyzed October 6, at 9 a. m., an interval of four days and seventeen hours.

Following are the results of the analyses :⁵

Indiana canes and sirups.

No.		Sucrose.	Other sugars.
		Per cent.	Per cent.
1	Sample of eight selected canes	13.25	2.30
2	Sample of sixteen average canes	10.73	3.71
3	Cane cut October 1	8.54	5.99

¹ *Op. cit.*, p. 43.

³ *Op. cit.*, p. 31.

⁵ *Op. cit.*, p. 53.

² *Bull. No. 2*, p. 32.

⁴ *Bull. No. 3*, p. 52.

Analyses were also made of canes from the Rio Grande plantation, New Jersey. These canes were prepared for shipment in the manner just described.

Analyses of juice from eight volunteer canes, ripe and in first-class condition :

	Per cent.
Sucrose.....	10.68
Glucose.....	3.25
Not sugar	2.48
Total solids.....	15.36

Analyses of six canes from field fertilized with salt muck :

	Per cent.
Sucrose.....	12.72
Glucose.....	1.77
Not sugar	3.23
Total solids.....	17.78

Analyses of twenty-five canes taken from carrier representing fairly well the canes ground on September 22, 1883 :

	Per cent.
Sucrose.....	9.32
Glucose.....	4.99
Not sugar	0.96
Total solids.....	15.27

In 1884 some small plats of sorghum were grown on the Department grounds. These varieties were Early Amber, Early Orange, Link's Hybrid, and Honduras. These plats had a dressing of well decomposed stable manure and an application of superphosphate equal to 400 pounds per acre.

Following is a description of the method of preparing the canes for analysis :¹

The seed-heads, as they appeared, were cut off of a large number of canes at intervals along the row. A like number of canes was left to mature in the usual way. To protect the forming seeds of these against the depredations of the English sparrows they were covered with a cap of tarlatan ; but in spite of this precaution the seeds did not mature. The hungry birds would hang upon the netting and gradually pick them off. To this extent the object of the trial was defeated ; but the results show that the removal of the seed, either before or after flowering, does apparently increase the percentage of sucrose in the juice. This is shown from the fact that the percentage of sucrose in canes deprived by the birds of their seed is much greater in the juices analyzed in 1884 than in those of 1883, when the seed matured. On the other hand, it does not appear that the removal of the panicle immediately on its appearance tends to give a materially greater percentage of sucrose than is obtained by allowing the birds to remove the seeds after they have begun to form.

In Table 1 are given the results of the analyses of canes whose panicles were cut as soon as they could be seen. These canes were stripped and pressed in a small mill. The percentage of juice expressed was noted. The bagasse was now passed a second time through the mill, and the percentage of second juice calculated on the first weight of the cane.

¹ Bulletin No. 5, Division of Chemistry, Department of Agriculture, pp. 139, 140.

Means of analyses of canes whose seed-heads had been removed.¹

First juices :	Per cent.
Sucrose	14.90
Glucose	1.32
Not sugar	3.71
Total solids	19.90
Purity co-efficient	74.80
Second juices : ²	
Sucrose	14.83
Glucose	1.25
Not sugar	4.99
Total solids	20.96
Purity co-efficient	70.50

Analyses of canes whose seeds were allowed to ripen.³

First juices :	Per cent.
Sucrose	14.72
Glucose	1.22
Not sugar	3.58
Total solids	19.59
Purity co-efficient	74.93
Second juices : ⁴	
Sucrose	14.60
Glucose	1.18
Not sugar	4.77
Total solids	20.67
Purity	70.54

Analyses of juices from stripped and unstripped canes.⁵

	Canes with seed heads cut.		Canes with seed heads uncut.	
	Stripped.	Unstripped.	Stripped.	Unstripped.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose	15.73	14.48	15.89	15.05
Glucose	1.57	1.99	1.36	1.99
Not sugar	3.37	2.84	3.32	2.79
Total solids	20.68	19.41	20.58	20.00
Purity co-efficient ..	75.99	74.52	77.02	75.22

I add the following observations : ⁶

JUICES OF 1884 COMPARED WITH THOSE OF 1883.

The most surprising phase of the experimental work as exhibited in the tables given is the great difference which it shows between the composition of juices analyzed and those analyzed during 1883 :

	1883.	1884.
Mean percentage sucrose	8.38	14.72
Mean percentage reducing sugars ..	4.09	1.24
Mean percentage albuminoids	.1544	.961

¹ *Op. cit.*, p. 141.³ *Op. cit.*, pp. 142, 143.⁵ *Op. cit.*, pp. 148, 149.² *Op. cit.*, p. 142.⁴ *Op. cit.*, p. 144.⁶ *Op. cit.*, p. 150.

The chief points of interest in this comparison are the increase in sucrose, the decrease in reducing sugars, and the increase in albuminoids. It is difficult to explain why the same varieties of cane grown in the same locality, with the same kind of culture and fertilizing, and in seasons not markedly different, should yield juice of such different composition. Sorghum is one of the most capricious of plants, and the above comparison brings some of its moods into strong contrast.

During the season of 1884 the Department made an extensive series of analyses at Helena, Wis.¹

The variety of cane was Early Amber, and it was grown in a light, sandy soil without fertilizers. I visited the plantation during the progress of the work. The cane, though small, looked well and was mostly ripe.

Following are the means of the analyses for the whole season:²

	Per cent.
Sucrose	7.85
Glucose.....	5.00

The proprietors of the plantation, Messrs. Williams & Flynn, even after the discouraging results of the above analyses, were not without hope that sugar-making could be profitably undertaken in Wisconsin. To this opinion I was not able to subscribe, as will be seen from the following quotation:³

In spite of the conviction of Messrs. Williams & Flynn that sorghum sugar can be made profitably in Wisconsin, I am far from being convinced of the justness of that expectation, unless, indeed, it be in some small way. In view of the disasters that have overtaken attempts at sorghum-sugar making further south I think it would be unwise to encourage like enterprises in regions where at best not more than four weeks of an average milling season can be expected.

In 1885 additional analyses were made of sorghum grown near Ottawa, Kans.⁴

The juices from the two mills used in grinding the cane were collected in a common tank and the samples for analysis taken from time to time from this tank. These samples, therefore, represent the mean constitution of the juice from several thousand tons of cane. The samples were taken from September 9 to October 14, inclusive:

<i>Means of the analyses.</i>		Per cent.
Sucrose		9.23
Glucose.....		3.04
Not sugar.....		2.87
Total solids.....		15.07

ANALYSES OF CANES USED IN DIFFUSION.

During the progress of the diffusion experiments at Ottawa, Kans., October 8, 1885, three samples of cane were taken at different times

¹ *Op. cit.*, pp. 151, *et seq.*

² *Op. cit.*, p. 154.

³ *Op. cit.*, p. 156.

⁴ Department of Agriculture, Division of Chemistry, Bull. No. 6, 1885.

during the day, and the juice, expressed on a small hand-mill, subjected to analysis. The following results were obtained :¹

	First analysis, 10 a. m.	Second analysis, 11 a. m.	Third analysis, 11.30 a. m.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Total solids....	17.00	15.60	15.20
Sucrose.....	11.24	9.63	9.83
Glucose.....	2.44	2.85	3.41
Not sugar	3.32	3.13	1.96

ANALYSIS OF DIFFUSION JUICES.

The diffusion juices obtained in the above experiment were analyzed with the following results :¹

	First sample.	Second sample.
	<i>Per cent.</i>	<i>Per cent.</i>
Total solids....	10.84	9.70
Sucrose.....	6.19	5.90
Glucose.....	2.32	2.00
Not sugar.....	2.23	1.80

Composition of canes used in second diffusion experiment at Ottawa.²

No.	Hour.	Sucrose.	Glucose.	Not sugar.	Total solids.
		<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1	10 a. m.	10.23	2.11	2.82	15.16
2	3 p. m.	8.64	2.95	2.81	14.40
3	4.30 p. m.	8.54	3.11	2.89	14.54
4	5.30 p. m.	8.81	2.61	2.98	14.40

Composition of diffusion juices from above canes.³

No.	Sucrose.	Glucose.	Not sugar.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
1.....	4.86	1.69	1.78	8.33
2.....	5.94	2.00	2.20	10.14
3.....	4.99	2.31	1.64	8.94
4.....	4.76	2.25	1.63	8.66
5.....	3.91	2.16	1.63	7.70
Means.....	4.89	2.08	1.76	8.74

Composition of juices from canes topped and suckered, topped and not suckered, and untouched, Ottawa, 1885.

MEANS.

	Topped and suckered.	Topped and not suckered.	Normal canes.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	12.45	12.46	12.15
Glucose.....	1.99	2.09	2.06
Not sugar	2.82	2.76	2.56
Total solids.....	17.26	17.31	16.77

¹ *Op. cit.*, p. 8.

² *Op. cit.*, p. 10.

³ *Op. cit.*, p. 12.

COMPOSITION OF CANES AND JUICES AT FORT SCOTT, SEASON OF 1886.

During 1886 the Department analyses were continued at Fort Scott, Kans.¹

Mean composition of juices of canes expressed by hand-mill.

August 30 to October 1, 1886:²

	Per cent.
Sucrose.....	10.49
Glucose.....	4.01
Total solids.....	17.56

October 1 to 26:

Sucrose.....	8.70
Glucose.....	4.15
Total solids.....	16.60

MEAN COMPOSITION OF DIFFUSION CHIPS.

These chips were taken from each cell and, after thorough mixing, sampled for analysis. The extractions were made in closed bottles.³

	In the cane.	In the juice.
September 8 to October 1, 1886:	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	8.85	9.73
Glucose.....	3.32	3.65
Total solids.....	14.69	16.15
October 1 to 28:		
Sucrose.....	7.01	7.71
Glucose.....	4.15	4.56
Total solids.....	14.90	15.99

COMPOSITION OF JUICES FROM DIFFUSION CHIPS.

Samples taken as just described and the chips passed through small mill.

*Means from October 15 to 28.*⁴

	Per cent.
Sucrose.....	7.28
Glucose.....	3.74
Total solids.....	14.80

*Composition of the canes calculated from the mill juices for the entire season.*⁵

	Total solids.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Before October 1....	15.63	9.34	3.57
After September 30..	14.77	7.74	3.79
After October 14....	13.17	6.48	3.31
Means.....	14.56	7.85	3.52

¹ Bulletin No. 14, Division of Chemistry, Department of Agriculture, 1887.

² *Op. cit.*, p. 15.

³ *Op. cit.*, p. 16.

⁴ *Op. cit.*, p. 17.

⁵ *Op. cit.*, p. 31.

MEAN COMPOSITION OF THE DIFFUSION JUICES FOR THE SEASON OF 1886.

Sampling.—From each cell as it was withdrawn a measured quantity of the diffusion juice was taken until an entire circuit of the battery had been made. The mixed samples was then subjected to analysis.¹

Mean composition of diffusion juices.

September 9 to October 1:		Per cent.
Sucrose.....		5.75
Glucose.....		2.32
Total solids.....		11.77
September 30 to October 28:		
Sucrose.....		4.90
Glucose.....		3.39
Solids		11.34

(b) WORK NOT DONE BY THE DEPARTMENT OF AGRICULTURE.

D. J. Browne² says the juice of sorghum grown in France contained from 10 to 16 per cent. sugar, a third part of which is sometimes uncrystallizable.

C. T. Jackson³ analyzed samples of sorghum canes sent him by the Department, and obtained from 9 to 12 per cent. saccharine matter to weight of stalk.

From samples grown in Massachusetts he obtained from 10.6 to 14.6 per cent. saccharine matter. He made no attempt to separate the different sugars in the juice.

In same volume, p. 313, is given an analysis made at Verrieres, France, showing 16 per cent. sugar, of which 10.33 is sucrose and 5.67 glucose.

C. T. Jackson reports further analyses in Agricultural Report, 1857, pp. 185 *et seq.*, in which the per cent. of saccharine matter varied from 9.36 to 16.6, and the sucrose from nothing to a large quantity, the exact amount of which was not determined. Dr. Jackson made no determinations of the sugar in the juice, but calculated the saccharine matter from the specific gravity.

J. Lawrence Smith⁴ made several analyses of sorghum, from which he concludes that "the sorgho contains about 10 per cent. crystallizable sugar."⁵

¹ *Op. cit.*, pp. 18, 19.

² Department of Agriculture. Report 1856, pp. 309-313.

³ *Op. cit.*, p. 308.

⁴ Agricultural Report 1857, pp. 192 *et seq.*

⁵ *Op. cit.*, p. 196.

Dr. C. A. Goessmann¹ gives the following as the means of his analyses of the ripe canes :

	Per cent.
Water	78.94
Soluble matter.....	10.22
Of which sucrose.....	9.25
Of which cellulose.....	8.20
Of which other substances	2.64

Joseph S. Lovering² found the following per cent. of sucrose in the juices of sorghum in several experiments, viz, 5.01, 5.57, 7.29.

Stansbury reports³ that the juice of sorghum, as examined in France, contains from 10 to 16 per cent. of sugar, a third part of which is uncrystallizable. In respect of the manufacture of sugar, he says :

In so far as the manufacture of sugar is concerned, in a domestic way, this plant appears to have but little chance of success in a high northern climate, as a large proportion of that which is uncrystallizable is not only a loss to the manufacturer, but an obstacle to the extraction of what is crystallizable. It must not be understood, however, that the produce of this plant is unprolific or difficult to obtain, but that, all things being equal, its nature renders it more abundant in alcohol or sirup than in sugar.

Hippolyte Leplay⁴ found a percentage of sucrose varying in ripe sorghum from 9.35 to 17.81.

Leplay⁵ shows a total content of both sugars from 7.81 to 11.81 per cent.

ANALYSES GIVEN BY F. L. STEWART.⁶

Stewart states that sorghum juices show an average density of 11° B., with 18° saccharine matter, nearly all of which is cane sugar.

After clarification this specific gravity is reduced to 9.5° B.¹

Average results for juice of ripe cane grown on good upland soil are given as follows :¹

Specific gravity.....	1.065
Specific gravity of clarified juice.....	1.070
Total sugars (per cent.).....	17.00

Of which nearly all is sucrose.

Stewart quotes the analyses of Dr. C. T. Jackson as follows :

Specific gravity.....	1.062
Calculated total sugar (per cent.).....	15.5
Obtained sugar (nearly all sucrose), per cent.....	16.6

The figures given in the Agricultural Report, already quoted for Dr. Jackson's analyses, are claimed by Stewart to be erroneous.

¹ Contributions to the Knowledge of the Nature of the Chinese Sugar-Cane, 1862, p. 21.

² Experiments on the Sorghum Saccharatum, 1857, pp. 7 and 14.

³ Chinese Sugar-Cane, 1857, p. 10.

⁴ Culture du Sorgho sucre, pp. 33 and 34, Toulouse, 1858.

⁵ Manuscript sent to author.

⁶ Sorghum and its products, 1867, pp. 171 *et seq.*

The reliability of the observations of Mr. Stewart may be called in question by the fact that he gives an illustration of a thin section of sorghum cane which shows an abundance of cane sugar crystals of a triangular shape. I will allow Mr. Stewart to describe these crystals in his own words:¹

An incontrovertible evidence of the presence of cane sugar almost exclusively in the juice of sorghum is afforded in the fact that thin sections of the fresh stalk of the plant under the microscope exhibit the cells filled with innumerable minute crystals of pure white sugar, which by their form and other criteria are shown to be cane sugar only. Scarcely a trace of any other substance is found in the cells. This is well represented in the engravings.

The means of analyses of Early Amber cane made by Professor C. A. Goessmann at the Agricultural College of Massachusetts in 1878 are as follows:²

	Per cent.
Sucrose	5.00
Glucose	6.35
Total solids	14.42

An analysis of the juice of the Amber cane at Berkeley, Cal., was made in 1879 by Professor Hilgard. It gave the following results:³

Specific gravity.....	1.0605
Total solids	per cent.. 14.8
Sucrose	do.... 10.1

Weber and Scovell⁴ give the results of numerous analyses of Amber and Orange sorghum. Following are the figures:

Composition of juice.

No.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>
1	10.75	3.84
2	4.90	5.70
3	12.48	2.47
4	7.12	6.19
5	11.42	2.13
6	9.13	5.00
7	11.02	2.79
8	9.76	4.11
9	10.06	2.47
10	13.11	1.82
11	9.67	2.94
12	11.41	4.02
13	3.55	14.66
Means	9.61	4.43

Weber gives the mean composition of the juice of orange cane as follows:⁵

	Per cent.
Sucrose	9.77
Glucose	3.00
Water	76.58
Starch	4.12

¹ *Op. cit.*, p. 186.

² Department of Agriculture, Report 1881 and 1882.

³ Report California College of Agriculture, 1879, p. 58.

⁴ Illinois Agricultural Report, 1880, pp. 425 *et seq.*

⁵ *Op. cit.*, p. 427.

Five samples of sorghum juice examined by Professor Hilgard, of Berkeley, Cal., in 1880, showed the following mean composition:¹

Specific gravity.....	1.081
Total solids	per cent .. 19.65
Sucrose	do 11.89
Purity.....	66.82

In 1881 Weber and Scovell continued their analyses.²

The means of three series of determinations of sucrose and glucose were found to be :

Series.	Sucrose.	Glucose.
	<i>Per cent.</i>	<i>Per cent.</i>
First ...	8.56	4.84
Second...	11.95	3.21
Third...	11.18	2.85

Weber and Scovell³ give the following as the mean composition of the juice of Amber cane for 1881 :

Specific gravity.....	1.070
Sucrose.....	per cent.. 12.08
Glucose	do.... 2.47

ANALYSES AT EXPERIMENTAL FARM OF WISCONSIN FOR 1881.⁴

The mean composition of the juice for 1881 at Madison, Wis., was—

	<i>Per cent.</i>
Sucrose.....	9.5
Glucose.....	3.2
Not sugar.....	2.3
Water	85.0

Analyses of Early Amber, Early Orange, and Honduras canes gave the following mean results :⁵

In the juice.	Early Amber.	Early Orange.	Honduras.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	10.68	10.50	7.00
Glucose.....	2.68	4.95	4.20

CANES FROM DIFFERENT PARTS OF THE STATE.

The mean composition of the juice from canes grown in different parts of the State of Wisconsin and sent to experimental station for analysis is as follows :⁶

	<i>Per cent.</i>
Sucrose	8.07
Glucose.....	5.12

¹ College of Agriculture, California, Report 1880, p. 41.

² Illinois Agricultural Report, 1881, p. 497.

³ Encouragement to the Sorghum and Beet Sugar Industry, Department Agriculture, 1883, p. 12.

⁴ Report National Academy Sciences on Sorghum, p. p. 80 *et seq.*

⁵ *Op. cit.*, p. 86.

⁶ *Op. cit.*, p. 80.

Weber and Scovell give the following as the mean composition of Amber cane for 1882.¹

Specific gravity	1.060
Sucrose	per cent.. 8.20
Glucose	do.... 3.66

For the best cane raised by them in 1882 the following mean composition of the juice is given:²

Specific gravity	1.060
Sucrose	per cent.. 10.17
Glucose	do.... 2.48

Swenson³ gives the analyses of juices from plots of fertilized canes grown at the experimental farms of the University of Wisconsin.

Following are the means of sixteen analyses:

	Per cent.
Sucrose	10.75
Glucose	3.09

Professor Swenson reports the mean percentage of sucrose in the juice of three lots of cane used for sugar making as follows:⁴

	Per cent.
Lot 1	9.89
Lot 2	12.13
Lot 3	11.20

Twenty-six varieties of sorghum grown on the experimental farm of Wisconsin in 1882 and analyzed by Professor Swenson showed the following composition of the juice:⁵

	Per cent.
Sucrose	9.84
Glucose	2.35

Twenty-three varieties grown with fertilizers at same place gave a juice of the following composition:⁶

	Per cent.
Sucrose	10.79
Glucose	2.81

Swenson also reports⁷ another set of canes which had a juice on October 13 of the following composition:

	Per cent.
Sucrose	10.59
Glucose	2.85

¹ Encouragement to the Sorghum and Beet Sugar Industry, Department of Agriculture, 1883, p. 12.

² *Op. cit.*, p. 16.

³ *Op. cit.*, p. 19.

⁴ Encouragement to Sorghum, etc., Department of Agriculture, 1883, p. 20.

⁵ Experiments with Amber Cane, Madison, Wis., 1882, p. 7.

⁶ *Op. cit.*, p. 8.

⁷ Encouragement to Sorghum, etc., Department of Agriculture, 1883, p. 21.

Three days later the juice had the following composition :

	Per cent.
Sucrose.....	9.50
Glucose.....	5.00

At Modena, Italy, during the same year, further experiments were carried on by Professor Pirotta.¹

The experiments were divided into four series. Following are the mean results for each series. In each series are given the means of twelve analyses of sorghum juices :

First series :

Specific gravity.....	1.0712
Sucrose.....per cent..	8.20
Glucose.....do....	6.53

Second series :

Specific gravity.....	1.0946
Sucrose.....per cent..	14.84
Glucose.....do....	5.14

Third series :

Specific gravity.....	1.0997
Sucrose.....per cent..	15.10
Glucose.....do....	5.81

Fourth series :

Specific gravity.....	1.1039
Sucrose.....per cent..	18.01
Glucose.....do....	4.17

In 1882 I made numerous analyses of juice from a large cane-mill at La Fayette, Ind. The analyses represent 50 acres of cane, the greater part of which was stripped and ripe.²

The means of the analyses are as follows :

Sucrose.....per cent..	7.59
Glucose.....do....	5.80
Specific gravity.....	1.0586

Fifteen varieties of sorghum were also grown on the experimental farm of Purdue University during the same year. The whole of the plots was cut and passed through the mill, and the analysis represents the composition of the entire juice.

The means are as follows :

Sucrose.....per cent..	7.17
Glucose.....do....	5.15
Specific gravity.....do....	1.059

Prof. Giulio Monselise³ gives the result of numerous analyses of sorghum juices. Following are the means of forty-one analyses made on canes planted in April, 1882 :

	Per cent.
Sucrose.....	11.35
Glucose.....	5.78
Total solids.....	18.60

¹ Annali di Agricoltura sul Sorgho Ambrato, 1883, pp. 28 *et seq.*, Roma.

² Report Agricultural College of Indiana (Purdue University), 1882, pp. 244-245.

³ L'ambra primitiva o Sorgho Zuccherino del Minnesota, Manitoa, 1883, Fascicolo Quarto; table opposite p. 192.

In 1882 experiments were made at the Zootechnic school in Reggio, Italy, by Professors Zanelli and Spallanzani. The means of the analyses made by them are as follows:¹

First series:

	Per cent. in the juice.
Sucrose	13.99
Glucose	4.97

Second series:

Sucrose	11.55
Glucose	7.82

Two samples of sorghum juice (early amber) examined by Professor Hilgard, of the University of California, showed the following mean composition:²

Specific gravity	1.070
Total solids	per cent. 17.00
Sucrose	do 8.10
Purity	45.40

A sample of juice from sugar-cane also grown in California showed the following composition:

Specific gravity	1.076
Total solids	per cent. 18.4
Sucrose	do 16.9
Purity	92.93

Professor Hilgard adds the following observations:³

The above analyses exhibit, first, the superiority of the true sugar-cane over the sorghum in respect to purity as well as total sugar contents, although in both respects the former is here shown below the quality to which it attains in tropical countries. There can be no doubt that wherever the tropical sugar-cane can be grown to advantage within the reach of intelligent labor and perfected appliances, it is superior to the sorghum as a sugar-producing plant.

Remarkable results were obtained by using special fertilizers in the New Jersey experiments.

In sixteen experiments the percentages of sugar in the cane were as follows:⁴ 15.05, 13.13, 12.97, 11.74, 11.40, 12.50, 15.01, 11.79, 12.70, 15.20, 12.59, 13.57, 15.42, 15.93, 16.09, 15.37. Mean calculated for juice, 15.16 per cent.

In 1883 two samples of sorghum juice were analyzed by Dr. H. P. Armsby, chemist of the Wisconsin Agricultural Experiment Station.

The results are given in the first annual report of the station, p. 79:

	No. 1.	No. 2.
	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose	6.15	7.85
Glucose	3.32	3.23
Total solids	12.00	13.50

¹ *Annali di Agricoltura sul sorgho Ambrato*, Roma, 1883, pp. 20 *et seq.*

² College of Agriculture, University of California, report, 1882, p. 61.

³ *Op. cit.*, p. 61.

⁴ New Jersey Experiment Station, Bull. No. XXX, p. 7.

Swenson¹ says the average percentage of cane sugar in sorghum grown by him on the Wisconsin farm was 10.5 to 12.5.

Weber² reports the following as the general average of all the cane juices manufactured at Champaign during the year 1883:

Specific gravity.....	1.059
Sucrose.....per cent..	7.78
Glucose.....do....	4.76

The means of seventy analyses made of Amber canes at Hutchinson, Kans., during the season of 1883, by Prof. M. Swenson, are as follows:³

	Per cent.
Total solids	14.2
Sucrose.....	9.3
Glucose.....	2.8

The means of thirteen analyses of the cane juices from the large mill at Hutchinson, Kans., give the following numbers:⁴

	Per cent.
Total solids.....	15.7
Sucrose.....	11.1
Glucose.....	3.3

The means of thirteen analyses of Orange cane at Hutchinson during 1883 are as follows:⁴

	Per cent.
Total solids.....	13.1
Sucrose.....	8.7
Glucose.....	3.5

Seven analyses of the juices of Link's Hybrid cane, made at same place in 1883, are as follows:⁴

	Per cent.
Total solids.....	13.2
Sucrose.....	10.3
Glucose.....	2.13

Means of two analyses of the juices of Honduras cane, made at the same time and place, are as follows:⁵

	Per cent.
Total solids.....	15.2
Sucrose.....	10.2
Glucose.....	3.4

The means of fifty-six analyses of the juices of sorghum, chiefly Amber, made by Prof. M. A. Scovell, at Sterling, Kans., in 1883, are as follows:⁶

	Per cent.
Sucrose	7.45
Glucose	3.58
Not sugar.....	3.13

¹ Third Annual Meeting Wisconsin Cane-Growers' Association, February, 1883, p. 16; edited by J. A. Field, Saint Louis, Mo.

² Department of Agriculture, Division of Chemistry, Bull. No. 3, p. 62.

³ *Op. cit.*, p. 64.

⁴ *Op. cit.*, p. 65.

⁵ *Op. cit.*, p. 66.

⁶ *Op. cit.*, pp. 67, 68.

The means of nine analyses of Early Amber cane juice, made by Prof. G. H. Failyer, of the Kansas State Agricultural College, at Manhattan, in 1883, are as follows :¹

	Per cent.
Total solids	15.35
Sucrose	11.72
Glucose	1.45

The means of six analyses made by the same person, at the same place, of the juices of Link's Hybrid cane, are as follows :¹

	Per cent.
Total solids	11.12
Sucrose	6.13
Glucose	2.83

Means of four analyses of Kansas Orange cane juice, made by the same person at same place and time, are as follows :¹

	Per cent.
Total solids	14.91
Sucrose	11.28
Glucose	1.06

One analysis of Honduras cane, made at the same time and place by Professor Failyer, gave—

Sucrose	per cent..	9.76
Glucose	do.....	3.29
Specific gravity		1.061

The means of sixteen analyses reported by F. L. Stewart are as follows :²

Specific gravity	1.068
Sucrose	per cent.. 12.50
Glucose	do..... 2.23

Prof. W. A. Henry³ reports the analyses of twenty-one samples of sorghum juices from different varieties.

The mean results are as follows :

	Per cent.
Sucrose	8.93
Glucose	2.34

In 1885 further analyses were made of field samples at the Rio Grande factory by the chemist of the New Jersey station, Dr. Neale.

All the samples except the last one named had been fertilized. The quantity of sugar in the cane of the several samples was as follows :⁴

¹ *Op. cit.*, pp. 68, 69.

² Fourth Annual Report New York State Sugar-Growers' Association, p. 44.

³ Second Annual Report Wisconsin Agricultural Experiment Station, p. 33.

⁴ New Jersey Experiment Station, Bull. No. XXXVIII, p. 10.

7.18, 7.56, 7.48, 6.57, 7.29, 7.14, 7.50, 6.26, 7.50, 8.19, 8.30, 7.54, 7.46, 6.46, 6.17. Mean calculated for juice, 7.96.

After the experiments above mentioned all the canes of the experimental plots were cut and passed through the large mill, and the expressed juices sampled and analyzed.

The respective percentages of sucrose in these juices were as follows: ¹ 8.69, 8.23, 9.96, 8.89, 9.70, 9.48, 9.96, 9.12, 11.30, 11.21, 11.38, 11.16, 11.03, 8.87, 9.18. Mean, 9.88.

Twenty-six tons of early orange cane was found by another analysis to contain 7.25 per cent. sucrose: ²

*Composition of sorghum juices from large mill at Rio Grande, N. J., for the four seasons from 1882 to 1885, inclusive.*³

SUCROSE.

[Averages for each week.]

1882. ⁴	1883. ⁵	1884. ⁶	1885. ⁷
<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
10.35	9.70	9.90	8.60
11.33	10.37	9.64	8.03
11.81	8.56	9.16	8.39
11.50	9.22	10.96	8.70
10.68	9.50	11.10	8.94
11.58	9.70	12.60	10.64
10.85	10.36	10.25	10.00
11.60	10.74	10.33	.....
10.56	9.95	9.90	.....
11.38	9.42	8.70	.....
11.11 ⁸	9.75 ⁸	10.25 ⁸	8.76 ⁸

⁴ From Sept. 4 to Nov. 6.

⁵ From Sept. 10 to Nov. 12.

⁶ From Sept. 8 to Nov. 10.

⁷ From Sept. 2 to Oct. 12.

⁸ Mean.

For 1886 the mean percentage of sucrose in the cane as reported by the New Jersey Experiment Station was 114 to 120 pounds per ton.

Mean in cane (pounds).....	117
Mean per cent, sucrose in cane.....	5.85
Mean per cent. sucrose in juice.....	6.54

The general average content of sucrose in the mill juices at Rio Grande for the five years is 9.28 per cent.

The means of ninety-eight analyses made in 1886 by Professor Stubbs, director of the experiment station at Kenner, La., were as follows: ⁴

	<i>Per cent.</i>
Sucrose	11.92
Total solids	16.34

¹ *Op. cit.*, p. 10.

² *Op. cit.*, p. 15.

³ MS. from Mr. H. A. Hughes, superintendent.

⁴ Louisiana Sugar Experiment Station, Kenner, La., Bull. No. 5, pp. 6 and 7, 1886.

In 1886 the New Jersey station continued its analyses at Rio Grande. The percentage of sucrose in the cane varied from 114 to 120 pounds per ton.¹

COMPARISON OF MILL AND DIFFUSION JUICES FOR 1886.

At Rio Grande the chemist of the New Jersey station made analyses for the purpose of comparing mill and diffusion juices.²

The means are as follows :

	Mill juice.	Diffusion juice
	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	8.93	7.59
Total solids.....	12.99	11.56
Purity.....	68.75	65.57

A mean of eight experiments made by J. F. Willcox, of New York,³ in 1886 shows 9 per cent. sucrose in sorghum juice.

ANALYTICAL DATA FROM THE EXPERIMENTS AT THE NEW JERSEY AGRICULTURAL STATION.

The systematic investigations made by Dr. Geo. H. Cook, director of the New Jersey Agricultural Experiment Station, have already been quoted in the data given. These experiments were commenced in 1881 and have been continued every year since. The chemical work has been in charge of Dr. A. T. Neale. The results of these experiments have been so interesting and instructive that I have grouped them together.

In 1881 fourteen varieties were planted, of which only five matured.⁴ The sucrose in the juice of these five matured varieties was as follows : Per cent., 8.58, 7.28, 6.50, 7.60, 14.06. Mean, 8.80 per cent.

The same season⁵ sixteen plots of Early Amber were treated with various fertilizers, and the yield of sugar calculated per acre.

The percentages of sucrose in the juice of the several plots were as follows: 9.70, 9.43, 9, 9.27, 9.68, 9.94, 10.51, 11.65, 11.43, 9.84, 9.57, 11.61, 9.73, 9.44, 12.01. Mean, 10.16.

In respect of the experiments Dr. Cook makes the following report:⁶

After a struggle, which has now lasted more than twenty-five years, sorghum to-day does not occupy its true position among sugar-producing plants. Its advocate justly claim that this is due to our lack of information, not only in regard to the manufacture of sugar from it, but also in respect to its proper cultivation. For some time past authorities have felt that the hope of having a small sugar-house on each farm must be abandoned, and that our attention must be turned towards the more rational

¹ Prof. G. H. Cook, *Rural World*, July 7, 1887.

² Seventh Ann. Report New Jersey Agricultural Experiment Station, 1886, p. 130.

³ MS. communication to author.

⁴ Second Ann. Report New Jersey Experiment Station, p. 43.

⁵ *Op. cit.*, pp. 44, 45.

⁶ *Op. cit.*, pp. 46, 47.

plan of thoroughly equipped manufactories, in which the sorghum grown on neighboring farms can be worked quickly and economically by skilled operatives.

The result of the season's experiments is decidedly encouraging, considering the unfavorable circumstances. There has been a drought of unprecedented severity and length, so that the corn crop on the college farm was not more than one-quarter its usual amount. And yet the results of sorghum growing on the same farm, as given in the above table, are respectable. With a season having the average rain-fall a crop weighing from two to three times as much as that of the present one may safely be calculated on.

In 1882 experiments were made on two plots on autumn and spring plowed ground. Each plot was divided into sixteen sections, on which different fertilizers were employed.

The mean percentages of sucrose in the juice for the two plots are as follows :¹

First plot.....	13.16
Second plot.....	12.2

The season was again reported as unfavorable.²

The plants came up quickly and grew rapidly from the first, so that no special trouble was experienced in hoeing or cultivating it. It came forward with strong and stout canes until near the middle of August, when a very severe drought set in. The growth of the cane was entirely stopped for some weeks, when it was about 6 feet high. Finally stunted-looking seed-heads partially developed in irregular patches and streaks over the field; most of the seed was blasted, and many of the stalks failed to head out. The height of the crop was 2 or 3 feet below the normal growth. When the rains came in September new shoots forked out from the upper joints and unfolded slender heads, but it was too late in the season, and no seeds ripened on them.

We judge that the crop of cane was not half what it would have been in a favorable season, and that of the seed not one-third of a full crop. The percentage of juice in the canes was also much lower than is natural in properly-grown sorghum.

The effects of the drought were irregular on the field, not following any of the lines which marked the plots and fertilizers, so that we can draw no satisfactory conclusions from the experiments on fertilizers either in the production of cane and seed or on the quality and amount of the juice or sugar.

Our uniform course is to record our failures as well as our successes, and this is published, though it is a disappointment and a failure which we could not avoid.

In 1883 the results of the experiments were still more encouraging.

The means of the percentages of sucrose in the juice of sixteen samples from as many different plots was 15.16.³

The average quantity of sugar produced per acre, based on the above analyses, was 3,963 pounds.

Some of the conclusions derived from the above set of experiments are of a remarkable character.⁴

Even when a mill expresses from 50 to 60 per cent. of juice from stripped and topped cane, it may yet leave more than one-half of the sugar in the bagasse. This fact can be best shown by an example. The cane on plot 11 contained 4,119 pounds of sugar per acre. Of this the mill expressed 1,983 pounds, leaving in the bagasse 52 per cent. of the sugar which the cane contained. This result is the most favorable in the experiment. The other extreme is found on plot 10, where nearly 70 per cent. of the sugar was

¹ Third Annual Report New Jersey Agricultural Experiment Station, pp. 64, 65.

² *Op. cit.*, pp. 61, 62.

³ Fourth Annual Report New Jersey Experiment Station, p. 70.

⁴ *Op. cit.*, pp. 67, 68.

wasted. In eleven other cases the loss exceeds 60 per cent. Apparently the greener the cane the smaller the loss of sugar by the milling process.

To explain this loss it is necessary to assume that a considerable portion of the sugar is stored in the cane in a solid state, either as pure crystallized sugar or in some combination easily decomposed or dissolved in water. It is claimed that the microscope has shown crystals of sugar in the cells of the sorghum; if this is true, it is irrational to attempt the perfect separation of sugar from the cane fiber by mechanical means. For attaining this end the process of diffusion seems to be the most practical and promising method. It has been thoroughly tested and generally adopted by the beet-sugar industry, and experiments thus far reported indicate that it is also applicable to the sorghum and tropical cane.

Mr. H. B. Blackwell states in the *Boston Journal of Chemistry* that by following this process he was able without difficulty to make 13 pounds of crystallized sugar and 6 pounds of good sirup from 100 pounds of Amber cane.

In my opinion natural crystals of sugar never exist in healthy sorghum canes. In 1883 I had this subject thoroughly examined.¹

Six hundred sections of sorghum and sugar canes failed to show a single crystal of sugar. In very dry seasons the juice of sorghum has been known to exude through perforations made by an insect and to crystallize on the outside of the stalk. A sample of very pure cane sugar formed in this way was sent to me last year (1886) by Mr. A. A. Denton, of Kansas.

In 1884 the following data were obtained as the result of the experiments at the station.²

There were sixteen plots Early Amber all fertilized but two. The percentage of sucrose in the cane was 8.53 and in the juice 9.39. The average total sugar per acre for the sixteen plots was 1,752 pounds. Two additional plots were planted in Amber and Orange canes respectively, no fertilizers being used.³

The total sucrose in the Amber plot was, for the cane 9.20 per cent., and for the juice 10.12 per cent.

For the Orange the numbers were: for the cane 6.57 per cent., and for the juice 7.22 per cent.

A plot of amber cane, from seed sent by Professor Henry, of Wisconsin, showed in the same conditions as above:⁴

	Per cent.
Sucrose in cane.....	8.63
Sucrose in juice.....	9.49

The intensely hot weather following May 14, the date of planting, was decidedly unfavorable for sorghum. The soil "baked" hard, the Amber seed germinated slowly, the "moping" period appeared to be unusually prolonged, and the plants in many hills perished, especially upon plots 12 to 16, inclusive. For a long time the experiment was regarded as a failure, and received comparatively little attention. Later the development was remarkable, and the yield of cane from several of the plots was above the average; in quality, however, in all cases it fell far below previous results.⁵

¹ Department of Agriculture, Division of Chemistry, Bull. No. 2, p. 6.

² Fifth Ann. Report New Jersey Agricultural Experiment Station, pp. 84, 85.

³ *Op. cit.*, p. 79.

⁴ *Op. cit.*, p. 80.

⁵ *Op. cit.*, p. 81.

In 1885 comparative experiments were made with native Amber seed, Amber seed from Prof. W. A. Henry, and native Orange seed.

The percentages of sucrose in the three kinds of canes were as follows:¹

	In the cane.	In the juice.
	<i>Per cent.</i>	<i>Per cent.</i>
Native Amber	8.98	9.87
Wisconsin Amber	10.40	11.44
Native Orange	7.38	8.11

Sixteen plots all fertilized save two were planted in Early Amber and the following data were obtained:²

Mean sucrose in canes	per cent..	9.37
Mean sucrose in juice	do....	10.30
Average weight sugar per acre	pounds..	2,372

Another set of experiments was made at Rio Grande with the co-operation of Mr. George C. Potts and Mr. H. A. Hughes. The following data were obtained. Early Orange cane, sixteen plots, all fertilized but one:³

Mean percentage sucrose in juice	9.88
Total weight sugar per acre	pounds.. 2,508

In reviewing the operations of the Rio Grande factory for the past five years, Professor Cook says:⁴

The records of this plantation for the past five years show that upon the average 7.7 tons of unstripped and untopped cane only have been grown per acre, while the average yield of merchantable sugar per ton of cane has not exceeded 40 pounds.

To compete successfully with other sources of cane sugar, therefore, the average tonnage of good cane per acre should be at least doubled, while the quantity of merchantable sugar secured per acre should be increased many fold.

In 1886 the experiments at Rio Grande were continued. Sixteen plots all fertilized but one were planted in Early Orange Cane. The following data were obtained:⁵

Cane (leaves and seed) per acre	pounds..	13,383
Clean cane per acre	do....	10,448
Sucrose in clean cane	per cent..	7.95
Total weight sugar per acre	pounds..	905

Professor Cook makes the following remarks on the results of the season:⁶

Three years ago it was clearly seen that the Rio Grande Company failed to secure one-half of the total amount of sugar present in its sorghum crops, and since that time all energies have been directed toward the substitution of diffusion for milling.

¹ Sixth Annual Report New Jersey Agricultural Experimental Station, p. 109.

² *Op. cit.*, p. 111.

³ *Op. cit.*, p. 126.

⁴ *Op. cit.*, p. 119.

⁵ Seventh Annual Report New Jersey Experimental Station, p. 151.

⁶ *Op. cit.*, p. 141.

The obstacles to this change, met at the very beginning, have at last been overcome, and 70 per cent. of the sugar in the cane has this year been extracted and sold. Information has also been gained which shows how 90 per cent. of the total sugar may be secured in the future.

It still remains to be demonstrated that this industry can be made a financial success.

The chemical analysis of cane, showing its percentage of sugar only, is far from reliable information on this question if unaccompanied by the actual weight of crop per acre.¹ A normal evaporation of water from a crop, for instance, may cause an apparent improvement in its quality, but as this evaporation is accompanied by a corresponding loss of weight, it leaves the absolute amount of sugar per acre unchanged. Again, the percentage of sugar in the juice may remain constant while the quantity of juice to be secured from an acre of cane may be steadily decreasing, involving thereby a loss in the absolute amount of sugar.

During the period October 9-23, 723 tons of unstripped and untopped sorghum were diffused, and an average yield per ton of 80 pounds of 100° test sugar thereby secured. Of this 80 pounds, 55.7 pounds crystallized and 24.3 pounds remained in the molasses. This cane was grown principally upon banked meadows, and although it may have passed its best stage as regards sugar production, it was not considered "dried up" or pithy.

On the 1st, 2d, and 3d of November 241 tons of unstripped and untopped cane were diffused, and an average yield per ton of 50 pounds of 100° test sugar thereby secured, of which 30 pounds crystallized and 20 pounds remained in the molasses. This cane was grown upon upland which had been heavily dressed with stable manure. Early in the fall it was considered a first-class crop, and, as it was within easy reach of the sugar-house, it was held in reserve to be used in case any emergency made it difficult to secure the necessary supply from more distant fields. This sorghum affords an unusual example of an over-ripe, pithy crop.

The green cane yielded 80 pounds and the pithy cane 50 pounds of 100° test sugar per ton. If, therefore, this loss of sugar was accompanied by losses in tonnage as heavy as farmers claim, then milling wastes at once sink into comparative insignificance. For if one-half of the tonnage disappears, and if at the same time that portion of the crop which remained depreciates 40 per cent. in value to the sugar boiler, it follows that two-thirds of the sugar formed in the plant may be wasted by delays in field-work.

This reasoning rests upon claims and assumptions which can be easily and thoroughly investigated; it indicates that the most important question now awaiting solution is, "At what stage in its growth should sorghum be harvested?"

MANUFACTURE OF SUGAR.

EXPERIMENTAL.

The first sorghum sugar made in this country appears to have been in an experiment by Dr. Battey, of Rome, Ga., in the laboratory of Dr. Booth in Philadelphia.²

We will give further results of experiments made at the South, and quote from the Southern Cultivator for October, 1856: "In the winter of 1844-'45 the junior editor of this journal obtained from Boston a few ounces of seed of this plant (Chinese sugar-cane), then newly imported from France. It came very highly recommended as a sugar-producing and forage plant; but, having a vivid recollection of many pre-

¹ *Op. cit.*, pp. 153 *et seq.*

² The Chinese Sugar-Cane, by James F. C. Hyde, New York, 1857, pp. 46 *et seq.*

³ This is probably a mistake and means 1854-'55.

vicious disappointments with new-fangled notions, we concluded to test it cautiously and moderately. Passing by it one day, when the seeds were nearly or quite ripe, we concluded to test the sweetness of the stalk; so cutting a moderate-sized cane and peeling its hard outside coat, we found an exceedingly sweet and pleasant flavor, wholly and entirely unlike anything of the corn-stalk family that we had ever tasted. It was, in fact, ready-made candy.

"Fully satisfied by this time that it was valuable, at least for the production of soiling, forage, and dried fodder, we next turned our attention to its saccharine properties, and fortunately induced our friend, Dr. Robert Battey, of Rome, Ga., who was at that time pursuing the study of experimental chemistry in the well-known laboratory of Professor Booth, of Philadelphia, to test it. As the result of his experiment Dr. Battey sent us three small phials, one containing a fine sirup, one a very good sample of crude brown sugar, and the other a very good sample of crystallized sugar. This we believe to be the first crystallized sugar made in the United States from the juice of the sorgho-sucr ."

Experiments were made by Joseph S. Lovering at Oakhill, near Philadelphia, in 1857, in the manufacture of sugar from sorghum. The first experiment was made September 30. In view of the voluminous literature on this subject in the thirty years that have passed since this experiment was made, I give Mr. Lovering's own description of it:¹

The fact of the presence of crystallizable sugar in the cane being established, I proceeded to cut and grind 20 feet of a row, and passed the thirty canes which it produced three times through the rollers; about one-fourth of the seed had changed to a dark glistening brown color, but was still milky; the remainder was quite green; ground six to eight of the lower joints, which together yielded 3½ gallons of juice, weighing 9° Beaume; neutralized the free acid by adding milk of lime; clarified with eggs and boiled it down to 240° F.

This first experiment looked discouraging and unpromising at every step; its product was a very dark, thick, viscid mass, apparently a *caput mortuum*; it stood six days without the sign of a crystal, when it was placed over a fire and kept warm four days longer, when I found a pretty good crop of soft crystals, the whole very similar to the "melada" obtained from Cuba, but of darker color.

Lovering's fourth experiment was made on one-fiftieth of an acre. It yielded 18.56 pounds of sugar and 23.73 pounds molasses.²

Calculated to 1 acre this gives 928 pounds sugar and 98.87 gallons molasses.

A foot-note informs us:³

Neither the scales in which this juice was weighed nor the quart measure in which it was measured were sufficiently delicate or accurate to give precise results, and as they form the basis of these calculations, the percentages are probably not absolutely exact, but they are sufficiently so for all practical purposes.

Three other experiments were made by Mr. Lovering, but with results less favorable than No. 4.

The fashion in excuses for failure in sorghum-sugar making was early set by Mr. Lovering.

In the fifth experiment⁴ he observed "a very sudden and unfavorable change in the working of the juice," which he ascribes to the weather "becoming and continuing very warm."

The sixth experiment, November 27,⁵ was made after warm Indian summer weather, with heavy rains, also very cold weather, making ice 2 inches in thickness, thermome-

¹ *Op. cit.* p. 7.

² *Op. cit.* p. 17.

³ *Op. cit.*, pp. 20-21.

⁴ *Op. cit.*, p. 16.

⁵ *Op. cit.*, p. 19.

ter having varied from 16° to 60°. To try the effect of these changes, I cut one-hundredth part of an acre, which produced 11.15 gallons of juice only, instead of 19 or 20 gallons, as before. It had, however, regained its former weight of full 10° B., but was much more acid, rank, and dark-colored than previously. It clarified without difficulty, but raised a much thicker and denser scum, and, when concentrated, was very dark and molasses-like; it, however, produced good, hard, sharp crystals, but the quantity being much reduced, there was no inducement to pursue it further. This experiment proves, however, that this cane will withstand very great vicissitudes of weather without the entire destruction of its saccharine properties.

On page 21 Mr. Lovering announces as a fundamental principle a rule of analysis which he followed, which, unfortunately, has not characterized all subsequent investigations. He says:¹

The foregoing are all actual results produced by myself (the polariscopic observations having been taken on the spot, under the supervision of my partner, Mr. William Morris Davis), with no object in view but the truth and a desire to contribute whatever useful information I could towards the solution of this interesting and important question.

But even thus early he was led into the error of making sorghum sugar on paper, a process which for ease and profit is far superior to making it from canes, and which, unfortunately, has been largely practiced since these days of initial experiments. Taking only his experiment No. 4, he figures a yield of 1,466.22 pounds of sugar and 74.39 gallons molasses per acre, adding²

Further, it will be observed that my acre produced but 1,847 gallons of juice. I have, however, seen published accounts of far greater yields than this—one for instance, in this county, apparently well authenticated, reaching 6,800 gallons per acre, which, according to my *actual* results would produce 4,499 pounds of sugar and 274 gallons of molasses, and according to the foregoing *probable* results, would yield 5,389 pounds of sugar and 274 gallons to the acre.

Mr. Lovering was also the first one to show (on paper) that sorghum was quite as fine a sugar-making crop as the sugar-cane in Louisiana. He makes the following comparison:³

	Louisiana.	Pennsylvania.
Yield of juice per acre gallons..	2, 236	1, 847
Density of juice (Bamé)..... degrees..	8.44	10.00
Yield of sugar per gallon of juice... pounds..	.76	.66
Yield of sugar per acre:		
Actual..... pounds..	1, 704	1, 221.85
Probable..... do		1, 612.00
Yield of molasses per acre:		
Actual..... gallons..	102	74.39
Probable..... do		81.83

As a result of the study of all his experiments, he arrives at the following conclusions:⁴

(1) That it is obvious that there is a culminating point in the development of the sugar in the cane, which is the best time for sugar making. This point or season I consider to be when most if not all the seeds are ripe, and after several frosts, say when the temperature falls to 25° or 30° F.

¹ *Op. cit.*, pp. 21 and 22.

² *Op. cit.*, pp. 23-24.

³ *Op. cit.* p. 25.

⁴ *Op. cit.*, pp. 26, 27.

(2) That frost, or even hard freezing, does not injure the juice nor the sugar, but that warm Indian summer weather, after the frost and hard freezing, does injure them very materially, and reduces both quantity and quality.

(3) That if the cane is cut and housed, or shocked in the field when in its most favorable condition, it will probably keep unchanged for a long time.

(4) That when the juice is obtained the process should proceed continuously and without delay.

(5) That the clarification should be as perfect as possible by the time the density reached 15° Baumé, the sirup having the appearance of good brandy.

(6) That although eggs were used in these small experiments, on account of their convenience, bullock's blood, if to be had, is equally good, and the milk of lime alone will answer the purpose; in the latter case, however, more constant and prolonged skimming will be required to produce a perfect clarification, which is highly important.

(7) That the concentration or boiling down, after clarification, should be as rapid as possible without scorching, shallow evaporators being the best.

With these conditions secured, it is about as easy to make good sugar from the Chinese cane as to make a pot of good mush, and much easier than to make a kettle of good apple-butter.

EXPERIMENT BY PROF. C. A. GOESSMANN.

In 1857 Professor Goessmann obtained from 1,440 grams of sorghum juice, by two crystallizations and washing the crystals with alcohol, 120 grams of sugar.¹ Professor Goessmann says:²

As I before mentioned, J. S. Lovering obtained in practice 7 to 8 per cent. of sugar without estimating the amount left in the molasses. I found from 9 to 9½ per cent. in the juice; and Mr. Wray, an Englishman, who examined several species of sorghum at Cape Natal, on the southeastern coast of Africa, found the percentage almost equal to that of the real sugar cane, 18 per cent. I mention these facts to show what may be expected when the sorghum shall have received the attention of our farmers and have become acclimatized on a suitable soil. The transplantation of a plant to a new and perhaps less congenial climate and soil invariably exerts at first an injurious influence on the vital principle and its products. When the beet root was first cultivated for the manufacture of sugar it contained only 7 to 8 per cent. of sugar, but by the application of proper care to the cultivation and to selecting the best specimens for seed the percentage was increased to from 11 to 12 in some species. Should it be possible to increase the percentage of sugar in the sorghum in the same ratio, its successful cultivation would become an accomplished fact; and our farmers, aided by their superior skill, more perfect machinery, and many other advantages afforded by this country, would be able to compete successfully with the planters of the West Indies.

Between the dates of the experiments recorded above and 1878 hundreds of successful attempts to manufacture sorghum sugar as a by product of molasses were made in the United States. I say successful in the sense that they demonstrated beyond any doubt the possibility of making sugar, although they threw no light on either the scientific or economic problems involved. I therefore omit any further discussion of them here.

Numerous experiments were made by Dr. Collier, chemist of the De-

¹ *Sorghum Saccharatum*, republished from Transactions N. Y. State Agricultural Society, 1861, p. 21.

² *Op. cit.*, pp. 26, 27.

partment of Agriculture in 1878, in the production of sugar from sorghum and maize stalks.¹

Dr. Collier says of these experiments :²

The point which these experiments have fully settled is, that there exists no difficulty in making from either corn or sorghum a first-rate quality of sugar, which will compare favorably with the best product from sugar-cane grown in the most favorable localities.

The experiments here given clearly indicate the probability that sugar may be thus made at a profit, and it is desirable that nothing be spared in continuing an investigation giving such fair promise of success.

The experiments in the production of sugar were continued by the Department of Agriculture in 1879.³ The sugar was not separated from the molasses except in one case, but the percentage of sucrose in the melada is given.

The melada from Chinese sorghum gave 54.7 per cent. sugar.⁴ Some of the analyses seem to show a loss of glucose, and in one instance this loss is given at 144.5 per cent.⁵

On this point Dr. Collier says :⁶

The presence of the same relative proportions of crystallizable and uncrystallizable sugar in a sirup to those present in the juice from which this sirup has been prepared by no means implies that there has been no inversion of the crystallizable sugar ; for the destructive action of an excess of lime upon glucose is well known and is not unfrequently made available in the production of sugar. Hence, it not unfrequently happens that the relative quantity of crystallizable sugar in the sirup may be greatly in excess of that present in the juice, even after a large quantity of the crystallizable sugar has been destroyed by inversion.

He adds :⁷

There is no doubt but that when the present industry shall have secured the employment of the capital and scientific ability which has developed the beet-sugar industry, even these results, which may appear extravagant to many, will be assured.

EXPERIMENTS AT THE ILLINOIS INDUSTRIAL UNIVERSITY, CHAMPAIGN, IN 1880.

These experiments were all directed by Professors Weber and Scovell. They undertook a series of experiments to determine the possibilities of manufacturing sugar from sorghum.⁸ Twelve experiments with amber and orange cane were made from September 17 to October 2.

In experiment No. 5 the sugar obtained, calculated to 1 acre, amounted to 710.67 pounds.

¹ Agricultural Report, 1878, pp. 98 *et seq.*

² *Op. cit.*, p. 99.

³ Agricultural Report, 1879, p. 53.

⁴ *Op. cit.*, p. 56.

⁵ *Op. cit.*, p. 61.

⁶ *Op. cit.*, p. 60.

⁷ *Op. cit.*, p. 56.

⁸ Transactions Department of Agriculture, Illinois, 1880, pp. 428 *et seq.*

Quantitative determinations were not made in the other experiments. As a result of their work the experimenters were led to make the following statement:¹

From the results above given it appears that crystallized sugar can be obtained from sorghum of as good a quality as that of the ordinary brown sugars found in the market. A portion of this brown sugar was re-dissolved and the solution passed through boneblack. On evaporation it yielded a white sugar, which had no trace of sorghum taste or smell.

From the proximate analysis of the cane, it appears that 1 acre of sorghum produces over 2,500 pounds of cane sugar. Of this amount we obtained 710 pounds in the form of good brown sugar, and 265 pounds in the molasses drained from the sugar. Hence 62 per cent. of the total amount of sugar was lost during the process of manufacture. This shows that the method of manufacture in general use is very imperfect.

The 710 pounds of sugar at 8 cents per pound would bring \$56.80. The molasses is worth 25 cents a gallon, or the products of an acre of sorghum would bring \$75.55. There is no doubt that, with proper care and apparatus, the above yield can be doubled.

From our experiments, it seems that about one-half of the sugar remains in the bagasse. This could, no doubt, in part be recovered by the process of percolation, as is sometimes done in the manufacture of beet-root sugar. Experiments will be made this coming season to determine the feasibility of recovering this great loss of sugar.

In 1880 Mr. H. A. Hughes manufactured some sirup from early amber cane near Cape May, N. J. This sirup was sent to a Philadelphia refinery and manufactured into sugar.²

EXPERIMENTS AT THE AGRICULTURAL STATION IN WISCONSIN IN 1881.

These experiments were conducted by Profs. W. A. Henry and M. Swenson.³ Two plots each of two-thirteenths acre area furnished the canes for experiments. On plot A there was made 142 pounds of sugar. On plot B there was made 109½ pounds sugar.

Calculated for an acre, plot A would make 923 pounds, and plot B would make 997½ pounds.

In regard to the character of the season, Professor Henry⁴ says:

I would state upon the whole that the season has not been a very favorable one
 * * * Had sugar been the object with our manufacturers this season, it would have been a very unfavorable one.

Weber and Scovell⁵ continued their work and made some very instructive experiments in the manufacture of sugar.

Experiment 1 (August 22):⁶

Weight of cane crushed	pounds..	1,560.00
Weight of juice obtained	do.....	687.50
Per cent. of juice		43.40

¹ *Op. cit.*, pp. 431-2.

² Fifth Ann. Report N. J. Agricultural Experiment Station, p. 86.

³ Report National Academy Sciences on Sorghum, p. 85.

⁴ *Op. cit.*, p. 92.

⁵ Transactions Dept. of Agriculture, Ill., 1881, pp. 500 *et seq.*

⁶ *Op. cit.*, pp. 500, 501.

The juice was carefully neutralized with milk of lime and brought to the boiling point in the defecating pan. A very heavy green scum rose, and this being removed, the juice was seen to be full of a green, light flocculent precipitate, which did not subsequently rise to the top in any considerable quantity. The juice was now drawn off into a tub, where it was allowed to repose twelve hours. At the end of this time only about one-half of the juice could be drawn off clear, the precipitate being still suspended in the remainder. It was found impossible to filter this portion, and it was, therefore, thrown away. The clear juice, after being passed through bone-black, was evaporated in a copper finishing pan to the crystallizing point. The melada had a very unpleasant, saltish taste, owing to the presence of salts of ammonia. The sugar crystallized very readily, and although it looked well, it still retained somewhat of this saltish taste after being separated from the molasses.

Experiment 2 (August 25):

Yield sugar per acre.....	pounds..	608.7
Yield sugar per ton	do....	77.2

Experiment 3:

Weight of cane.....	pounds..	1,440
Weight of melada obtained	do....	145.8
Weight of sugar not given.		

Experiment 4:

Weight cane.....	pounds..	1,161
Weight melada from juice.....	do....	95.5
Weight sugar from juice.....	do....	41.5

The authors add the following observations: ¹

- (1) Seed should be planted as early as possible.
- (2) The proper time to begin cutting the cane for making sugar is when the seed is in the hardening dough.
- (3) The cane should be worked up as soon as possible after cutting. Cane which cut in the afternoon or evening may safely be worked up the following morning.
- (4) The manufacture of sugar can be conducted properly only with improved apparatus, and on a scale which would justify the erection of steam sugar-works, with vacuum pans, steam defecators and evaporators, and the employment of a competent chemist to superintend the business. The same is true for the manufacture of glucose from the seed. Our experiments were made with the ordinary apparatus used in manufacturing sorghum sirup, and any person who desired to work on a small scale could use the methods with good results, provided he had acquired the necessary skill in neutralizing and defecating the juice and in the treatment of the bone-black filters. The manufacture of glucose on a small scale is entirely out of the question. Five hundred to a thousand acres of sorghum would be sufficient to justify the erection of steam sugar-works, and this amount could easily be raised in almost any community within a radius of 1 or 2 miles from the works."

Fourteen quantitative experiments were made by the Department of Agriculture in 1882 in the production of sugar. These experiments are described by Dr. Collier as follows: ²

In the fourteen experiments which were made, quantitatively, eleven of the sirups were a solid mass of crystals; in two of them two-thirds of the sirups were mush sugar, and in the remaining sample the sirup contained a few crystals of sugar, but the analysis showed that this one had not been evaporated quite to the point of good crystallization.

¹ *Op. cit.* 502, 503.

² Investigations of Sorghum, Special Report, 1883, pp. 55 *et seq.*

**EXPERIMENTS FOR WHICH AN AWARD OF \$1,200 WAS MADE
BY THE COMMISSIONER OF AGRICULTURE.**

(1) CHAMPAIGN, ILL.

The Champaign Sugar and Glucose Manufacturing Company in 1882 submitted a report of its operations to the Commissioner of Agriculture, of which the following is a summary:¹

Number tons cane worked for sugar.....	1,723.99
Number acres cane.....	185.8
Pounds sugar manufactured.....	86,603.00
Pounds sugar per ton	50.3
Pounds sugar per acre	465.5

A part of the crop was so poor in sucrose that it was worked for molasses only. The climatic conditions attending the experiments are described as follows:²

The weather during this year, so far as planting, cultivating, maturing the crop, and the development of cane sugar in sorghum in this section of the country has been the most unfavorable of any year within our knowledge, and we are informed by those who have grown sorghum and broom-corn that this year has been the most unfavorable season for upwards of twenty years in this section for those crops.

Further difficulties in manufacture are also described.³

The company were unfortunate in not having a crystallizing-room, capable of being heated to the proper temperature for the best results in crystallization, and the subsequent purging of the sugar. The room was so cold that the melada was too stiff to arrange itself evenly in the centrifugal without the addition of warm water in the mixer, and even then it was often found impossible to purge without washing with warm water. We took the trouble to make experiments to see how much or what proportion of sugar was being washed down with and into the molasses by reason of the cold. It was done by taking a certain weight of melada, 120 pounds, which was carefully warmed and then swung out. The yield was 56 pounds of dry sugar. The same amount of melada from the same car was swung in the usual way, and the yield was 38 pounds of dry sugar, or a loss of 18 pounds of sugar in a purge, by reason of the cold. We had but a few days of favorable weather, and the results from it compared favorably with the above experiment.

Upon that basis we find that there was uselessly washed away 27,799 pounds of sugar. Add sugar obtained, 86,603, and, with a suitable crystallizing-room kept at a temperature of from 98° to 100°, the sugar product would have amounted to 114,402 pounds. This would have made the yield per ton of 66.3 pounds; yield per acre, 615.7 pounds.

This sugar was actually made, and was lost in separation by reason only of the fact that it could not be kept at the proper temperature. This difficulty can be overcome by having a crystallizing-room and having it kept properly heated.

In the next place sorghum requires hot summer weather for its proper development. As shown in our report, the average temperature during the part of the past season fell far below the usual summer temperature in this section, and was an average of 6° below the average of the same months of last year.

¹ Encouragement to sorghum, etc., 1883, p. 13.

² *Op. cit.*, p. 11.

³ *Op. cit.*, pp. 17, 18.

(2) REPORT OF PROFESSOR SWENSON.

Magnus Swenson¹ reports three experiments :

	Stripped cane.	Sugar.	Yield per ton.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
Three and three-fifths acres gave	75,263	2,116.5	56.3
Two acres gave.....	23,974	1,008	70
One and one-fourth acres gave.....	17,112	594	69

Owing to the very backward season the growth of the cane was exceedingly slow.²

In respect of the purity of the juice Professor Swenson says: ³

I do not believe that the average juice from the sorghum cane is of sufficient purity to allow of its being boiled to grain in the vacuum pan. I obtained a much coarser sugar by allowing the crystallization to take place in small tanks, and it was consequently much more easily separated.

Compare this with the statement of Professor Weber: ⁴

During our season's work in running the vacuum pan for sugar we did not fail at any time to produce crystals therein of proper quantity and desirable size.

(3) REPORT OF MR. PAUL STECK, OF SAN FRANCISCO, CAL.⁵

Four hundred acres of cane were planted. Mr. Steck puts his daily expenses, aside from the cost of cane, at \$235.50. His premium of \$1,200 therefore only paid his running expenses for a little over five days.

I give below that part of his report where we might expect to find a statement of the quantity of sugar made.⁶

I manufactured from 600 to 650 gallons of sirup per day; average market price 50 cents per gallon. The reason why I could not manufacture sugar in quantity was on account of the juice not crystallizing in the vacuum pan, as cane sugar should do, so I was compelled to let the sirup run into tanks for crystallization. The sirup which I manufactured from this sorghum was superior to any in the market, both in color and taste. The time required in making the alterations necessary and the putting in of large tanks, and other changes which I would have to make, was too short, so I converted the crop into sirup, as above stated. The sorghum sirup has a very slow crystallization, and the room in which it is kept should have a temperature of not less than 105°. It is a very important point in manufacturing sugar from sorghum not to bring the juice to boiling-point, as it checks the crystallization; therefore it should always be evaporated in vacuum pans (what we call single, double, and triple effect), and also the cane brought to the mill should be manufactured into sugar or sirup within twelve to fifteen hours, as the longer it is exposed to air the more sucrose will turn to glucose. There should not be more cane cut in the field than can be worked at the mill each day.

¹ *Op. cit.*, pp. 19 *et seq.*

² *Op. cit.*, p. 20.

³ *Op. cit.*, p. 23.

⁴ *Op. cit.*, p. 15.

⁵ *Op. cit.*, pp. 23 *et seq.*

⁶ *Op. cit.*, p. 25.

In the summary of his report, however, we have the following curious information :¹

Number of acres of sorghum brought to the mill.....	300
Number of tons of cane manufactured	3,600
The yield of sorghum per acre.....tons..	15
The amount of sugar manufactured (about).....tons..	5
The amount yielded per ton of cane (about)...pounds..	80 to 90

Mr. Steck, it seems, had equal difficulty in making sugar and computing yield per ton. Had heavy floods and frosts not occurred, and the factory had been large enough, Mr. Steck states that he would have made 288,000 pounds.² The loss of 278,000 pounds is therefore to be attributed to the unfriendliness of nature.

Mr. Steck closes his report with a promise which he has never performed, viz :

My intention next year is to manufacture sugar from sorghum, knowing the exact process necessary to its manufacture.

(4) REPORT OF NELSON MALTBY, GENEVA, OHIO.³

Mr. Maltby makes the following statement of his work :⁴

I worked up cane from 17½ acres; the weight of the cane was 167 tons and 824 pounds, yielding a little over 9½ tons per acre. I made 1,466 gallons sirup not to be granulated. I made 1,095 gallons of sirup for sugar, weighing 12 pounds per gallon, all of which grained well. I made 4,380 pounds good dry sugar from the same. From some cane I made 72 pounds sugar and 112 pounds sirup per ton. The average was 62 pounds sugar and 124 pounds sirup per ton.

(5) REPORT OF DRUMMOND BROS., WARRENSBURGH, MO.⁵

The number of tons of cane manufactured was 243, an average of 9½ tons per acre. The greater part of this product did not crystallize.

The sugar obtained was wholly from the Early Amber variety, and amounted to 1,464 pounds, being an average of 50 pounds per ton. Calculated on the whole quantity of cane, however, it is not quite 7 pounds per ton.

Drummond Bros. make no complaint of the unfavorableness of the season.

(6) REPORT OF A. J. DECKER, OF FOND DU LAC, WIS.⁶

Mr. Decker, in competing for the prize of \$1,200 for sorghum-sugar making, naively remarks in his summary of operations :

	Gallons.
Full amount of sirup made this year.....	3,600
Vinegar.....	800
Sugar (not yet swung out). ⁷	

¹ *Op. cit.*, p. 25.

⁴ *Op. cit.*, p. 27.

⁶ *Op. cit.*, pp. 31 et seq.

² *Op. cit.*, p. 26.

⁵ *Op. cit.*, pp. 28 et seq.

⁷ *Op. cit.*, p. 36.

³ *Op. cit.*, pp. 26 et seq.

The date of Mr. Decker's report is not given. He says, however :¹

On September 22 and 23 there was a sharp frost. The cane was mostly in blossom and the juice tested 5° B. Three months later it tested less than 6° B. There is, therefore, internal evidence that the report was written later than December 23.

This failure to separate the sugar may have been due to the small capacity of the centrifugal, which² "was small, 24 inches in diameter, 6 inches deep, with a capacity of 500 pounds per day."

In respect of the weather we learn :³

The season has been the most unfavorable of any known in this locality since the introduction of this crop.

Mr. Decker closes with a number of observations to which the preceding part of his report gives great emphasis :⁴

There are a number of points requisite to the development of sugar from sorghum as well as the process of manufacturing. First, is ripe cane; second, proper appliances; third, "the know how." The long-continued high degree of heat required in open-pan boiling destroys nearly all the sugar long before the required density is reached, and under the most favorable circumstances not more than one pound of sugar to the gallon can be expected from open-pan work, and that does not deserve to be called sugar making yet. I believe with the use of the vacuum pan and the skill to run it, sugar in the West is as certain as making flour from wheat.

(7) REPORT OF WILLIAM FRAZIER, ESQ., VERNON COUNTY, WIS.⁵

The weight of cane manufactured by Mr. Frazier was nearly 259 tons, grown on a little more than 41 acres. Mr. Frazier's success in sugar making can not be properly appreciated save in his own words :⁶

My report on this subject can not be what I would like. I am able, however, to send you what I believe to be a pretty fair sample of crude sugar; it was dried from sirup made of Mr. Brigg's cane, dried by draining the sirup through a coarse cloth. Allow me to state here that my object has been sirup, with a view of making sugar in the near future. The most of my sirup was thoroughly grained one week after it was made. Had it granulate in the coolers frequently. My coolers are 8 inches deep and hold 40 gallons each.

On two occasions there was about an inch in the bottom of the second cooler so completely grained that it would not run out, although the melada was quite warm. I now have about 2,500 pounds of sugar in the bottom of sirup tanks, which I intend to throw out in the spring.

Mr. Frazier also finds fault with the weather :⁷

But the expected spring rains failed to come. It continued very dry until the 24th day of June, when nearly 4 inches of rain fell in one day, many heavy rains following, making it impossible to work our crops until the season was far advanced. I replanted my cane twice, but owing to the cold, dry spring and to the ravages of the grub worm, failed to get half a stand on the 19-acre piece.

(8) REPORT OF THE JEFFERSON SUGAR COMPANY, JEFFERSON, OHIO.

We manufactured 33,250 pounds of melada from the 190 tons of cane worked. We have not separated all of it in the centrifugal as yet; but it is running about 4 pounds per gallon (or for every 12 of melada), from the first granulation. We expect on re-

¹ *Op. cit.*, pp. 31 and 32.

³ *Op. cit.*, p. 31.

⁵ *Op. cit.*, pp. 36 *et seq.*

⁷ *Op. cit.*, p. 41.

² *Op. cit.*, p. 35.

⁴ *Op. cit.*, p. 36.

⁶ *Op. cit.*, p. 38.

⁸ *Op. cit.*, p. 46.

boiling twice to raise the figures to 7 pounds. Last year we got 6 pounds in every 12, with two boilings, from some of the best cane. If we do not succeed in getting more than 6 pounds per gallon, we will have from the above figures 16,625 pounds sugar. This would be nearly 90 pounds sugar per ton of cane, and about 700 pounds per acre of land. We feel assured of this much from the yield of that already separated; but we hope to obtain an average of 7 pounds per gallon from all of the cane worked for sugar during the present season. If cane had fully matured we should not want to stop with less than 8 pounds per gallon.

The weather, as usual, was bad :

The last two seasons have been the most disheartening ones for developing this new industry that our country has seen for years.¹

(9) REPORT OF THE OAK HILL REFINING COMPANY, EDWARDSVILLE, ILL.²

The report says :³

And now we must state plainly that we have not manufactured sugar *on a business scale* this season. That is, we have simply made a small quantity as samples of our work, and contented ourselves with turning out the greater part of our products as sirup. We did this for several reasons.

In the first place, during the two previous years the juice, at its best (and seldom so), had been on the ragged edge; that is, scarcely enough sugar to crystallize under the most favorable circumstances. In 1880-'81 the best "quotient of purity" (i. e., polarization divided by solid contents) was about equal to the lowest boilings in a sugar refinery, where a vacuum pan is needed, and three weeks' storage in a "hot room" to insure a yield of 25 per cent. in sugar, and afterwards a bone-black filtration to give the sirup a salable color. In 1881-'82 the cane, if anything, was poorer; we had fine-looking ripe cane, the stalks of which were sticky with exuded juice; it had been in the society of the chinch-bug, and the juice polarized from 1 to 2 per cent. This year the chinch-bug had been hard at work improving the time as far as possible, and we knew what to expect.

As to the weather, etc., the report says :⁴

The past three years the chinch-bugs have been very troublesome in this section. They have done great damage to the cane crop, especially severe in dry seasons, as the past three have been.

(10) REPORT OF C. BOZARTH, CEDAR FALLS, IOWA.⁵

Mr. Bozarth introduces his report as follows :⁶

I want to preface by stating that I have been in the business twenty-four years, and this has been the worst year for cane that we have had for sixteen years. We had a very cold, wet, backward spring. The cane was four weeks coming up, after which there were a number of hard frosts, the weather continuing cold and wet up to July, which so delayed the crop that it was not much past the bloom when frost came again on the 22d of September, leaving the cane poor in sweetness and weight, both marking only 6° to 8° Baumé and averaging not more than 7°. I have made but little sugar this season, hardly enough to pay for running through the centrifugal machine, and inasmuch as the sirup is a good price I have not thought best to put it through for the little that is in it, although there is a considerable granulation through all my sirup, fully as much this year as I could expect, and more, considering the quality of cane. Last year I had 5,000 pounds that sold in the market for

¹ *Op. cit.*, p. 43.

³ *Op. cit.*, p. 51.

⁵ *Op. cit.*, pp. 57 *et seq.*

² *Op. cit.*, pp. 47 *et seq.*

⁴ *Op. cit.*, p. 55.

⁶ *Op. cit.*, p. 57.

8½ cents per pound, and the year before 15,000 pounds that sold for 8 cents per pound. I raised this year on my own farm 85 acres, which was all worked without stripping.

The introduction contains all there is in this report concerning the production of sugar.

The results of the experiments just abstracted are appropriately preceded by a summary made by the Commissioner of Agriculture of the experiments which had been made up to that time by the Department of Agriculture in the production of sugar from sorghum. He says:¹

On assuming the duties of my office in 1881 I found 135 acres of sorghum, containing fifty-two varieties, which had been planted in Washington for the use of the Department. On being informed that the time had arrived for manufacturing sirup and sugar, I engaged the services of an expert in sugar-making who had been highly recommended for the position of superintendent, and operations were commenced on September 26 at the mill erected by my predecessor on the grounds. These operations were continued with slight interruptions until the latter part of October, at which time the supply of cane became exhausted. Forty-two acres of the crop were overtaken by frost before being sufficiently ripe for use, and this portion of the crop was so badly damaged as to be unfit for manufacture. The yield of cane per acre on the 93 acres gathered was 2½ tons; the number of gallons of sirup obtained was 2,977, and the number of pounds of sugar was 165. The expense of raising the cane was \$6,589.45, and the expense of converting the cane into sirup and sugar was \$1,667.69—an aggregate of \$8,557.04.

To recapitulate the results of the ten experiments I give the following table:

Sugar made.	Pounds.
No. 1.....	86,603
No. 2.....	3,718.5
No. 3 (about).....	10,000
No. 4.....	4,280
No. 5.....	1,484
No. 6.....	0,000
No. 7.....	0,000
No. 8 (estimated).....	10,000
No. 9.....	0,000
No. 10 ("a little").....	
Total sugar.....	116,165.5

Amount of premium given, \$12,000. Amount per pound (nearly), 10.3 cents.

BY THE DEPARTMENT OF AGRICULTURE.

PRACTICAL.

Attempts were made in 1881 by the Department of Agriculture to manufacture sugar at Washington. Cane from 93.5 acres was crushed. From the official report it does not appear that any success attended these efforts.

The causes of failure are thus set forth by Dr. Collier:²

Briefly stated, the several chief sources of failure are as follows:

(1) The immaturity of the sorghum at the period when it is cut and worked. This may be due to late planting, as in our experience the past season, or to the selection

¹ *Op. cit.*, p. 3.

² Agricultural Report, 1881-2, pp. 509 *et seq.*

of a variety which requires more time for its complete maturity than the season in any given latitude may give. The importance, then, of selecting only such varieties as will mature sufficiently long before frosts, so as to give a reasonable time to work up the crop, can not be overestimated.

(2) Another frequent cause of failure is due to allowing the sorghum to remain some time after being cut up before it is worked at the mill. That such a course may be pursued in certain seasons and in certain localities without producing an unfavorable result has been established beyond much doubt, but the climatic conditions which render such a procedure possible are imperfectly understood at the present, and repeated experiments have demonstrated that after being cut up the juices are subject to chemical changes which speedily result in the destruction of the crystallizable sugar. For the present, then, the only safe course to pursue is to work up the cane within at most twenty-four hours after it is cut up.

(3) A third cause of failure exists in an imperfect method of defecation of the juice. The object of defecation and the method by which it is accomplished should be carefully studied and as thoroughly understood by the sugar-boiler as is possible, for, although somewhat complex in its details, the general principles which underlie this important step are few and easily comprehended.

The report of the engineer in charge of the work, Mr. J. H. Harvey, gives the following summary:¹

Cane crushed	pounds..	458,444
Juice obtained.....	gallons..	26,794
Sirup obtained	do....	2,977
Sugar made.....	pounds..	165

Mr. Peter Lynch, sugar expert, makes the following statement concerning the work:²

Peter Lynch, who had the general management of the sorghum business, superintending its manufacture into juice, sirup, and sugar, says that he has had fifteen years' experience as a sugar-boiler with Cuban molasses, cane sugar, grape sugar, etc.; that of the 206½ gallons of light sirup obtained October 5 and 6, 1881, there were from 175 to 200 pounds of sugar obtained—nearly 1 pound per gallon. It was good sugar, worth 8 to 9 cents a pound, wholesale; would polarize between 96 and 98. No special means were used to obtain this result. It was boiled to a proof that would granulate. The juice from which this was made contained on an average from 2.8 to 3½ per cent. of glucose and from 11 to 13½ per cent. of cane sugar.

The mill worked excellently, and every particle of juice possible was extracted. Had this same quality prevailed with all the season's juice, the same average quality of sugar would probably have been obtained every day.

The only canes really worth anything were those worked that day. On other days the proportion of glucose was greater, owing to bad cane. Do not think the quality of sirup made this year as fair an average as might be expected with fair soil, fair climate, etc. Good soil ought to raise from 16 to 18 tons of stripped stalks.

For the results of the season's work no blame can be attached to the machinery or anything else. The only cause for failure to make sugar was that the cane was not sufficiently ripe.

In 1883 572,350 pounds of sorghum cane were worked for sugar by the Department at Washington. The machinery employed was that used by Dr. Collier in the work of 1881.

The quantity of sugar made was 7,160 pounds, or 1.24 per cent. of the cane worked, or 24.8 pounds per. ton.³

¹ *Op. cit.*, p. 522.

² *Op. cit.*, p. 523.

³ Department of Agriculture, Division of Chemistry, Bulletin No. 3, p. 43.

Forty-two tons of clean cane grown in Indiana were also worked for sugar. The quantity made was 2,860 pounds, or 3.39 per cent., equal to 67.8 pounds per ton.¹

Further attempts were made by the Department in Ottawa, Kans., in 1885 to manufacture sugar from sorghum. The process of diffusion was employed. Expensive machinery was provided and one satisfactory trial was made. Unfortunately the actual number of tons of cane used could only be estimated. The estimate was based on the weight of *masse cuite* obtained, and is without doubt very nearly correct. The quantity of sugar made was 1,420 pounds, estimated at 95 pounds per ton.² A subsequent trial failed to produce any sugar.³

Further attempts were made by the Department in 1886 to manufacture sugar from sorghum at Fort Scott, Kans. The diffusion process was employed. The average weight of *masse cuite* was 12 per cent. of the weight of the cane used.⁴ The weight of cane worked for sugar was 2,322 tons.⁵ The weight of sugar made was 50,000 pounds.⁶ Weight sugar per ton, 21.6 pounds.

MANUFACTURING TRIALS WITHOUT THE DEPARTMENT.

I could not give here all the incidental attempts at making sugar which have been made in connection with the manufacture of molasses from the time of the introduction of the sorghum plant into this country to the present time. I will confine myself to a brief review of the attempts which have been made to produce sugar.

CRYSTAL LAKE, NEAR CHICAGO.

I believe the first attempt to make sugar from sorghum on a large scale in this country was at Crystal Lake, near Chicago. The factory was under the direction of Mr. J. B. Thoms. According to the report of the National Academy of Sciences on sorghum—⁷

In 1879, with a "miserable mill," he obtained juice of 8½° B. (specific gravity 1,060), and from a gallon of sirup weighing 11 pounds got a yield of about 4½ pounds to the gallon. He obtained from 15 to 23 gallons of sirup to the ton of cane, weighing 11½ pounds to the gallon, the sirup yielding 4½ pounds sugar, polarized 53°. Of amber cane, which is the only sort he has worked, has known as high as 21 tons cut to an acre, and states 12 tons as an average. He sold of the crop of 1879 over 50,000 pounds of good C sugar, which was tested in Boston and New York, and polarized 96½ per cent. of sugar. In 1880 his crop of about 300 acres was nearly all destroyed by a hurricane and the product of about 30 acres of damaged cane was all made into sirup, which polarized only 42 per cent.

¹ *Op. cit.*, p. 52.

² Department of Agriculture, Div. of Chemistry, Bul. No. 6, p. 9.

³ *Op. cit.*, p. 13.

⁴ Department of Agriculture, Div. of Chemistry, Bul. No. 14, p. 36.

⁵ *Op. cit.*, p. 35.

⁶ *Op. cit.*, p. 36.

⁷ Report Nat. Acad. of Sciences, p. 36.

Further data concerning operations at Crystal Lake and Hoopeston I give in quotations from the communication of Mr. Thoms to the committee of the National Academy:¹

In the first place let me state to you I am a practical sugar refiner; spent some eight years in the West Indies making sugar from cane. So you will perceive I came here well armed in the knowledge of the business of sugar making. In August, 1879, I saw sorghum for the first time, and although the works were put up by inexperienced persons, besides being so near the time for grinding the cane, we had not much chance to make the necessary alterations, so had to get along as well as we could; and as the cane was new to me, and I had little or no faith in its sugar-producing qualities, I resolved to treat it with as much delicacy as a mother would her sick child.

In consequence of the vacuum-pan boiling the sugar so hot, and not being familiar with the juice, and wishing to get as large a yield of sugar as possible, I boiled it rather stiff, which made the grain finer than I wished it, but to the experienced that did not detract one iota from its strength. I continued to run until I had made over 50,000 pounds of sugar.

In 1880 we had made alterations in order to do some pretty good work; planted about 300 acres of cane, and a month before it matured it was struck by a hurricane and damaged to such an extent that we received only the product of 30 acres; that, mixed with dead cane, rendering the juice so bad that the sirup only polarized about 42 per cent. Boiled some for sugar, but finding it very gummy abandoned the idea and made only sirup. Thus ends the chapter for 1880. In 1881 the spring was so backward our cane hardly matured, and the sirup from it polarized about the same as the previous year (42½ per cent). Having such bad luck the past two years at Crystal Lake, Ill., where the above experiments were tried at the works of F. A. Waidner & Co., we have concluded to abandon any further work at the above place. I should here state that Crystal Lake is the most elevated section in the State of Illinois which makes raising a crop there rather uncertain; although the old residents of the place say they never experienced two such years with sorghum as 1880 and 1881; indeed, that is the general verdict throughout the country. Crystal Lake is situated about 44 miles north of Chicago. I am interested in a large works at Hoopeston, Ill., which is attached to a corn-canning establishment erected for the purpose of utilizing corn-stalks. That we found was no go, as the stalks had but little juice; could not produce enough sirup to pay expenses. I consider the corn-stalks had a thorough test. We found only about a foot or a foot and a half of the stalk to contain juice; the rest was a dry pith. At the time the corn was in the roasting-ear. The corn-stalks were tested in 1880. In 1881 we cultivated 500 acres of sorgho, and the drought was so severe we only got about 2½ tons to the acre, instead of from 10 to 20. Cane was very thin and in some instances not over 2 or 3 feet long, sirup only polarizing 40; did not attempt to make sugar. This year we are putting under cultivation at Hoopeston 1,000 acres. We sold all of our product last year by the car-load in this city at 50 cents per gallon.

Notwithstanding I have been here three seasons I have not had a single day's fair trial of sorgho juice. With the plant of machinery we have at Hoopeston now to work up juice such as I had in 1879, I am sure the results I could produce would astonish the country.

I am satisfied of one thing, that the cultivation of the cane is not thoroughly understood. One great drawback here has been the want of proper machinery and a knowledge how to treat the juice. They imagine all that is necessary is to boil out the water and let nature do the rest.

¹ *Op. cit.*, pp. 119, 120.

I have been a very careful student for the last three years, and consider myself now familiar with the juice, and just want one fair chance. They were thirteen years in Louisiana before they could successfully make sugar from ribbon cane. We did it here in six weeks."

I will add that the further attempts to make sugar at Hoopeston were total failures, and both factories have been abandoned and dismantled.

FARIBAULT, MINN.

In 1879 a factory was built at Faribault, but no sugar was made.¹ In 1880 5,000 pounds sugar were made.² In 1881 there are several conflicting reports of the amounts made. Blakeley reports 7,000 pounds.³ He also reports the amount at 11,000 pounds.⁴ The total amount made during the season is also given at 15,000 pounds.⁵

The manufacture of sugar having proved financially unsuccessful further operations were abandoned and the factory closed.

CHAMPAIGN, ILL.

A large factory was built at Champaign, Ill., in 1882. This factory was under the immediate supervision of Professors Weber and Scovell. Professor Weber says:⁶

As a result of the experiments carried on by the writers in the seasons of 1880 and 1881 the Champaign Sugar and Glucose Company, of Champaign, Ill., was organized. The object of the company was to carry out on a commercial scale the production of sugar and glucose from sorghum, as was indicated by our laboratory experiments. The company was organized with a capital stock of \$25,000. The total expenditure for building the works and raising the crop, however, exceeds \$30,000.

The committee of the National Academy⁷ say:

In 1882 the results of the sugar mill at Champaign, Ill., are reported as being very satisfactory to owners.

Several hundred thousand pounds of white sugar were made in that and the two following seasons. The venture, not proving profitable, was abandoned.

HUTCHINSON, KANS.

This factory was built in 1882, but the first year failed to produce any sugar. In 1883 about 200,000 pounds of sugar were made, but at a heavy loss.

In 1884, 250,000 pounds of sugar were made, but still with a loss. Further attempts were then abandoned and the factory has been dismantled.

STERLING, KANS.

The first season's work of this mill, 1882, resulted in the production of a very small quantity of sugar. In 1883, 170,000 pounds were made.

¹ Blakeley, Report Nat. Acad. Sciences on Sorghum, p. 35.

² *Op. cit.*, p. 35.

³ *Op. cit.*, p. 36.

⁴ Third Ann. Meeting Wis. State Cane-Growers' Association, p. 33.

⁵ Report Nat. Acad. of Sciences on Sorghum, p. 30.

⁶ *Op. cit.*, p. 78.

⁷ *Op. cit.*, p. 34.

In 1884 a little over 100,000 pounds sugar were manufactured and the business was then abandoned as unprofitable.

FRANKLIN, TENN.

The disasters which attended the fortunes of this company, 1883-'84, were not softened by the production of sugar. The young sugar-boiler at first secured a few crystals in his pan. Each day, however, the results were poorer, "and at the end of one week no trace of sugar could be found, and in mortification he left without notice and has not yet been heard from."¹

OTTAWA, KANS.

A large glucose factory here was converted into a sorghum-sugar factory. Sugar was made in considerable quantities in 1884 and 1885, and the house was then shut up, the business being attended with financial loss.

RIO GRANDE, N. J.

This factory is the most extensive and thoroughly equipped of any sorghum-sugar house ever built in the United States.

For five successive seasons from 1882 it was conducted with the highest skill. With the aid of a State bounty of \$1 per ton for the cane and 1 cent a pound for the sugar, the company was able to hold together financially. With the close of 1886 the State bounty expired and the factory has now been closed and dismantled, since it could only be run at a loss without the bounty. In all nearly 1,500,000 pounds of sugar have been made by this company.

In speaking of the operations of the large factories the committee of the National Academy says:²

One signal success, on a large scale, obtained by intelligent attention to the results of experimental research and skillful culture, opens the way to a repetition of like results.

It is from the States of New Jersey and Illinois that we are able to cite examples of success on so large a scale and attended with such a satisfactory result as fairly puts to rest any doubts as to the production of sugar, on a great scale, in a northern climate with a commercial profit.

How sadly the members of the committee suffered themselves to be deceived the financial ruin of the above two "successes" has attested.

At the present time, May, 1888, there remains only one sorghum sugar factory on a large scale in the country, viz, at Fort Scott, Kans. One is building at Topeka and one at Conway Springs, Kans. Col. Cunningham, Sugar Lands, Tex., is also preparing to make sorghum sugar in connection with the sugar-cane.

DISCUSSION OF THE DATA.

Having thus collected from every available source the results of the analyses of sorghum juices made by different investigators, except those

¹ Department of Agriculture, Div. of Chemistry, Bull. No. 5, p. 165.

² Report National Academy of Sciences on Sorghum, pp. 30, 31.

recorded in Bulletin 17 and Professor Stubbs's Bulletin No. 12, it ought to be possible to weigh them justly and to form some approximately accurate idea of the value of sorghum as a sugar producer.

First of all, it will be necessary to divide the analytical data into two classes, viz: (1) Data derived from the analyses of small samples, in other words, experimental data, and (2) those obtained from analysis of large quantities of material entering in the process of manufacture; in other words, manufacturing data.

I have collected below all the mean analyses of experimental samples, and have obtained therefrom a general average of the character of all the juices which have been analyzed in a small way.

BY THE DEPARTMENT.

Authority.	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Wetherell	4.29	6.08	.....
	4.13	7.00	.....
	6.19	8.65	.....
Erni	10.31	2.07	.....
Antisell	11.10	8.90	.....
	7.86	4.38	.....
	5.94	3.60	.....
Collier	14.60	.....	.....
	13.80	.....	.....
	13.80	.....	.....
	14.60	.....	.....
	10.63	2.44	.....
	12.41	2.47	.....
	13.17	2.14	18.41
	10.95	2.95	17.08
	9.89	3.85	.....
	8.45	2.90	.....
	9.88	2.17	.....
	10.48	1.33	.....
	11.45	1.20	.....
	12.25	1.12	.....
	12.63	1.45	.....
	10.29	3.21	15.34
	14.64	1.67	18.06
	11.79	1.15	15.97
	13.31	0.98	17.62
	12.44	1.23	16.35
	14.35	2.85	20.18
Wiley	9.04	4.08	14.81
	13.25	2.30	.....
	10.73	2.71	.....
	8.54	5.99	.....
	10.68	3.25	15.36
	12.78	1.77	17.78
	9.32	4.99	15.27
	14.90	1.32	19.90
	14.63	1.25	20.96
	14.72	1.22	19.59
	14.00	1.18	20.67
	14.48	1.09	19.41
	15.73	1.57	20.68
	15.89	1.36	20.58
	15.05	1.99	20.90
	11.24	2.44	17.00
	9.62	2.85	15.60
	9.63	3.41	15.20
	10.23	2.11	15.16
	8.64	2.95	14.40
	8.54	3.11	14.54
	8.81	2.61	14.40
	12.45	1.99	17.26
	12.46	2.09	17.31
	12.15	2.06	16.77
	10.49	4.01	17.56
	8.70	4.15	16.60
Averages	11.34	2.80	17.37

ANALYTICAL DATA OBTAINED WITHOUT THE DEPARTMENT

Authority.	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Browne.....	7.00	3.00	.....
Jackson.....	11.00	5.00	.....
Smith.....	10.33	5.67	.....
Goessmann.....	11.00	2.20	.....
Goessmann.....	10.94	.....	.....
Lovering.....	5.01	.....	.....
.....	5.57	.....	.....
.....	7.29	.....	.....
.....	9.35	.....	.....
Leplay.....	17.81	.....	.....
Goessmann.....	5.00	0.35	14.43
Hilgard.....	10.10	.....	14.80
Weber & Scovell.....	9.61	4.43	.....
Weber.....	9.77	3.00	.....
Hilgard.....	11.89	.....	.....
Weber & Scovell.....	8.58	4.84	.....
.....	11.95	3.21	.....
.....	11.18	2.85	.....
.....	12.08	2.47	.....
Henry & Swenson.....	9.50	3.20	15.00
.....	10.63	2.68	.....
.....	10.50	4.95	.....
.....	7.00	4.20	.....
.....	8.07	5.12	.....
Weber & Scovell.....	8.20	3.66	.....
.....	10.17	2.48	.....
Henry & Swenson.....	10.75	3.09	.....
.....	9.89	.....	.....
.....	12.10	.....	.....
.....	11.20	.....	.....
.....	10.59	2.85	.....
.....	9.50	5.00	.....
Plotta.....	8.20	6.53	17.14
.....	14.84	5.14	22.00
.....	15.10	5.81	23.50
.....	18.01	4.17	24.50
Wiley.....	7.17	5.15	14.70
Monselee.....	11.35	5.78	18.00
Zanelli & Spallanzani.....	13.99	4.97	.....
.....	11.65	7.82	.....
Hilgard.....	8.10	.....	17.00
Armsby.....	6.15	3.32	12.00
.....	7.89	3.22	13.50
Swenson.....	9.29	2.80	14.20
.....	8.70	3.50	13.10
.....	10.80	2.13	13.20
.....	10.20	3.40	15.20
Scovell.....	7.45	3.83	14.41
Fallyer.....	11.72	1.45	15.35
.....	6.13	2.83	11.12
.....	11.22	1.06	14.91
.....	9.76	3.29	15.00
Stewart.....	12.50	2.23	16.50
Henry.....	8.93	2.34	.....
Neale.....	7.96	.....	.....
.....	9.88	.....	.....
.....	7.25	.....	.....
Stubbs.....	11.92	.....	16.34
Neale.....	8.93	.....	12.99
Willcox.....	9.00	.....	.....
Cook & Neale.....	8.80	.....	.....
.....	10.16	.....	.....
.....	13.16	.....	.....
.....	12.20	.....	.....
.....	15.16	.....	.....
.....	9.39	.....	.....
.....	10.12	.....	.....
.....	7.22	.....	.....
.....	9.49	.....	.....
.....	9.87	.....	.....
.....	12.44	.....	.....
.....	8.11	.....	.....
.....	10.30	.....	.....
.....	9.88	.....	.....
.....	7.95	.....	.....
Averages.....	10.00	3.83	15.90

Means of the two sets of data:

	Per cent.
Sucrose	10.67
Glucose	3.32
Total solids	16.68

The means of the above means of experimental analyses show that, taken as a whole, even small quantities of sorghum have not been particularly suitable for sugar-making.

If, however, we study the analyses in detail, it will be seen that the sorghum often develops a surprisingly high content of sucrose, an amount in fact which, could it always be produced and kept long enough to allow of its manufacture, would place sorghum in the front rank of sugar-producing plants.

ANALYSES OF JUICES EMPLOYED IN MANUFACTURE.

We turn with lively interest from the experimental laboratory to the large factory.

Unfortunately the promises of a laboratory experiment are not always performed in actual practice, and in the case of sorghum sugar-making this fact is emphasized.

Following are the means of the analyses of samples of large quantities of sorghum juices entering into the defecating pan.

The lessons which these mean analyses teach us of the nature of sorghum juice when produced on a large scale for manufacturing purposes are far more valuable from a practical point of view than the teachings of an experimental laboratory.

The mean analyses are taken from the data already given. Those from Weber and Scovell and Weber are from the factory at Champaign, Ill.; those marked Scovell from the factory at Sterling, Kans.; those marked Swenson from the Hutchinson factory; those marked Collier from the large operations conducted by the Department of Agriculture at Washington; those marked Neale and Hughes from the factory at Rio Grande, N. J., and those marked Wiley from the large operations carried on at Washington, Helena, Wis., Ottawa and Fort Scott, Kans.

The means of these analyses show as accurately as possible the character of sorghum grown on a large scale in the United States from 1880 until the present time.

These are figures which do not deal with the future and the ideal, but set forth in a convincing light what has actually been accomplished in the growing of sorghum as a sugar-producing plant on a large scale.

I believe I have incorporated in these general means the average numbers representing the composition of all the sorghum juices which have entered into manufacturing on a large scale of which analyses have been made :

Means of analyses of sorghum juices manufactured into sugar.

Analysts.	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Collier.....	6.94	6.38	15.22
Whey.....	8.38	4.09	14.06
	6.73	6.16	.....
	7.85	5.00	.....
	9.23	3.04	15.07
	9.73	3.65	16.15
	7.78	4.56	15.99
	7.28	3.74	14.80
	7.52	5.80	14.50
Weber.....	7.78	4.76	.....
Swenson.....	11.10	3.30	15.70
Hughes.....	11.11	.....	.....
	9.75	.....	.....
	10.25	.....	.....
	8.76	.....	.....
Neale.....	6.64	.....	.....
Averages.....	8.54	4.50	15.19

We come, therefore, to the somewhat surprising result that the mean percentage of sucrose in the juices of sorghum grown on a large scale and entering into the manufacture of sugar in the United States during the past six years is only 8.54 per cent.

The mean co-efficient of purity of these juices is 56.2 and the per cent. of available sugar on the basis of difference between per cent. sucrose and sum of the percentages of other solids, 1.89. Allowing an average extraction of 60 per cent. of the weight of cane, the theoretical yield per ton for the time indicated, supposing there was no loss in manufacture, would be 22.68 pounds. By diffusion extracting 93 per cent. of the sugar, and calculating available sugar as sucrose less glucose multiplied by 1.4, the theoretical yield per ton would have been 35.5.

These figures need no comment. They show beyond any question that the failure to make sorghum sugar profitably in this country has not been due alone to defective machinery nor lack of skill, but chiefly to the quality of the cane which has been used.

These practical results are strongly in contrast with the conclusions of the committee of the National Academy of Science, who, basing their statements on the results of the analyses of small samples of carefully cultivated cane, reached results which in no manner represent the actual data of experience. The committee says :¹

These analyses have shown the constitution of the juices of each variety at the successive stages in the development of the growing plant. They not only confirm the well-known fact of the presence of sugar in the juices of these plants in notable quantity, but they also establish beyond cavil what seems surprising to those who have not examined the facts, that the sorghum particularly holds in its juices, when taken at the proper stage of development, about as much cane sugar as the best sugar-cane of tropical regions.

¹ Report National Academy of Sciences on sorghum, p. 43.

It is particularly unfortunate that such a fallacious conclusion should have been published on such high authority, not so much because of the harm it has done and will do, but chiefly because it is constantly used by unscrupulous persons to bias the minds of those who have not time to investigate this matter for themselves, thus hindering the knowledge of the truth.

A strenuous effort has been made in certain quarters to convey the impression that nothing has been learned about sorghum since the report of the Academy was published and that any person who calls in question its infallibility is unworthy of public confidence.

But what shall we think of the care exercised by the committee in forming its conclusions on this matter when we find it at the same time indorsing the corn-stalk sugar theory in the following terms? ¹

By reference to the tables it will also be seen that of the eight varieties of maize examined in 1881, seven of which were of common field and one of sweet corn :

	Per cent. of cane sugar.
3 analyses of 3 varieties gave over.....	13
9 analyses of 7 varieties gave over.....	12
22 analyses of 7 varieties gave over.....	11
29 analyses of 7 varieties gave over.....	10
35 analyses of 7 varieties gave over.....	9

Of ten varieties of maize grown in 1880, the following results were obtained :

	Per cent. of cane sugar.
124 analyses of 10 varieties gave over.....	9
90 analyses of 10 varieties gave over.....	10
59 analyses of 9 varieties gave over.....	11
24 analyses of 9 varieties gave over.....	12
8 analyses of 4 varieties gave over.....	13
2 analyses of 1 variety gave over.....	14
1 analysis of 1 variety gave over.....	15

In 1880 over 62,000,000 acres of our land were in maize, or 33 per cent. of all the cultivated land of the United States. The amount of sugar thus apparently lost, calculated on the results obtained at the Department of Agriculture in the last three years, is equal to the present product of the entire world. It is premature to say that the profitable extraction of sugar from corn-stalks is demonstrated, but such a result may yet be possible.

The only trial on a large scale for extracting sugar from corn-stalks of which we have record will be found in the statement of J. B. Thoms, of date April 10, appended to this report (p. 119), and was not a success. *It is possible that if the maize had been allowed to mature, in place of being cut when the ear was in an immature state fit for canning, the result might have been different.*

I have taken the liberty of italicizing the last sentence, since it is one of the most remarkable scientific generalizations that has ever met my view.

I will add that the committee were extremely modest in limiting the corn-stalk sugar to the whole sugar production of the world. Sixty-four million acres of maize would give not less than 640,000,000 tons of corn-stalks. The mean per cent. of sucrose as given by the committee is 11.6. The total quantity of sugar which is, therefore, annually wasted

¹ *Op. cit.*, pp. 44 *et seq.*

in our corn stalks is 74,240,000 tons. Since the annual production of sugar for the whole world is only 6,000,000 tons, it is seen that by a failure to utilize the means of wealth which were so carefully pointed out we waste a quantity of sugar twelve times larger than the whole product of the world.

But this is a theoretical computation. Let us take the actual yields which the committee found had been obtained:¹

It will be seen that in successive years there was also obtained from the stalks of common maize, *after the ripened grain had been plucked*, at the rate of 900 pounds of sugar to the acre. It also appears from the correspondence submitted that many parties have practically secured results nearly equal to these in their work.

At 900 pounds per acre 64,000,000 acres would give 57,600,000,000 pounds, or 28,800,000 tons.

Those of us who have been brought up on a farm and know by experience the exceptionally juicy and saccharine character of the corn stalk when the ears are fully ripe can appreciate the explanation which the committee makes of Mr. Thoms' failure to secure sugar from the stalks. *Credat Judæus Apella.*

The above opinions show the danger of forming conclusions which from insufficient data or from data which are partial, are not safe guides to the whole truth.

It is evident, therefore, that the committee of the academy, having now before them the data derived from the attempts at manufacture on a large scale, to which I have referred, would compile a summary wholly different from that given in their report.

There is one fact, however, which is emphasized in the analytical data which demands careful attention. It is seen by numerous analyses of the juices of a single or a few stalks of sorghum that they are capable of furnishing a large yield of sugar.

The question therefore arises, "May not a whole crop of this kind be produced?"

Without referring to the analyses which were made before, it will be sufficient to cite those made by the Department at Fort Scott, Kans.

I call attention first to some analyses made of the juices of a few canes expressed by a small "hand-mill":²

Date.	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sept. 19	13.54	2.97	20.00
Sept. 22	14.50	2.77	21.20
Sept. 24	13.53	2.41	18.70
Sept. 30	12.59	3.76	17.80
Oct. 2	14.50	1.77	20.20
Oct. 3	14.37	2.16	20.70
Oct. 5	13.20	2.37	19.70
Means	13.72	2.60	19.76

¹ *Op. cit.*, p. 48.

² Department of Agriculture, Div. of Chemistry, Bul. No. 14, p. 15.

With such cane juices, although they are not as pure as the average sugar-cane juice in Louisiana, it would not be difficult, in my opinion, to make sugar profitably. The data which I give are easily duplicated in those of former years, but this point is so well settled that I will not dwell longer on it here.

In contrast with this I will cite an equal number of analyses made in the same circumstances : ¹

Data.	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sept. 16	7.04	7.60	19.00
Sept. 23	3.60	11.36	20.20
Oct. 1	3.37	4.95	15.50
Oct. 5	9.95	4.88	18.80
Oct. 9	4.55	9.62	18.30
Oct. 12	6.65	4.72	14.40
Oct. 13	5.71	11.41	21.50
Means	6.56	7.82	18.26

It seems almost incredible that two sets of analyses so entirely different in their results could have been made on samples taken in identically the same manner. This remarkable fact discloses the great difficulty which the sugar maker working on sorghum has to encounter, viz, the unreliability of his raw material.

This difference between seven of the best analyses and seven of the poorest ones, made during the same season, is not more remarkable, however, than the differences between two sets of such experiments made under similar conditions by the New Jersey station.

In the data already quoted we find :

	1883.	1886.
Sucrose in juice.....per cent..	15.16	7.95
Total sugar per acre .....pounds..	3,963	9.05

These two illustrations set forth in a most striking form the tendency to acute and extensive variations which the sorghum plant has shown ever since its introduction into this country.

The worker in sugar cane and sugar beets is reasonably sure of his material. What it is to-day it will likely be to-morrow and so continue sensibly until the end of the season. Unhappily the sorghum-sugar worker has no such assurance. The same variety of cane, in the same degree of maturity, will show the most surprising differences in the sugar content of its sap.

Prof. Hippolyte Leplay has noticed this variation especially, from year to year, and has ascribed it to the process of degeneration. He says : ²

The culture and distillation of sorghum cane had given such important results in Algiers that Mr. Hardy, director of the Central Government nursery at Algiers, announced, as results of his experiments, that from 1 hectare (2.47 acres) of sorghum,

¹ *Loc. cit.*

² MS. to author, p. 5 *et seq.*

when the price of alcohol was 171 francs per hectoliter (26.40 gallons), he could realize a profit of 8313 francs, and with the price of alcohol as low as 70 francs per hectoliter, the profit from 1 hectare would be 3340 francs.

Under the influence of these encouraging results, the question as to the culture and distillation of sorghum could not be doubtful.

The most important establishments were able to distill from 8,000,000 to 10,000,000 kilograms of sugar cane in the districts of Haute-Garonne, Pyrénées-Orientales of Vaucluse, and in Algiers.

Five years later, that is to say, in 1862, all this grand agricultural and industrial movement had disappeared, all the large and small distilleries had closed, with great losses, and the culture of sorghum cane was almost entirely abandoned.

What have been the causes of these great reverses after the grand success of the beginning so generally and so well established?

Certain circumstances have led the author of this article to occupy himself personally in the culture of sorghum, mostly with a view to its industrial utilization. He took an active part in the grand movement of which sorghum was the object in 1856 to 1862; he has followed all the phases of its prosperity and of its decadence as propagator and as victim; he has been able to study the causes of the failure and the means of avoiding it, but the discouragement from all sides became too great for him to examine with coolness and mature thought or to attempt new efforts. In 1863 he finally abandoned sorghum, which every one else had already given up, as the captain abandons his ship at last, when it sinks under his feet, and the distillery "St. Michel," at Avignon, was, like the other establishments, closed up and abolished. Since that time, and until within the last few years, sorghum has given no signs of life and no further publications upon the subject have been made; but generations pass, the defeats of the past lose their intensity, prejudice is dissipated, and there is born of these disasters a new breath of youthfulness which creates new projects.

We have studied much into the details and the causes of this failure in France in many manufactories established in the south for the distillation of the cane using several millions of kilograms of stalks each season. The first year the production in alcohol was, from 100 kilograms of stalks, 7.50 liters or quarts, or 22 pounds.

The second year the production from the same amount of stalks was 6 liters; the third year, 4.50 liters; the fourth year, 2 liters.

It was discovered that the cause of this reduction in the quantity of alcohol, and consequently in the quantity of sugar, was due to the fecundation of the sugar cane by the broom cane, or *Sorghum vulgare*, which is cultivated in great quantities in the same localities. The crossing is caused by the pollen from the broom cane being carried by the winds to the sugar cane, and the consequence of this fecundation was that the seeds which had received this attaint, when resown, produced stalks full of white pith without juice, like the stalks of broom corn, or stalks half pithy, which, instead of containing 90 per cent. of juice, contained only 15 or 20 per cent., and this juice was of a quality which produced a small quantity of sugar.

All means employed to overcome this imperfection were without success. One could distinguish by the peculiarities of the spike those stalks which had not been tainted by the pollen from the broom corn, but this influence was invisible in the seed, which had been fecundated by the pollen to such an extent that, although taken from stalks containing 15 per cent. sugar and sown the following season, would produce only degenerated cane.

We have seen stalks of sorghum cane produced from the planting of seeds from the same spike, of which the primitive stalk contained 16 per cent. of sugar, give bunches of seeds and single seeds presenting such entirely different characteristics that they would serve to constitute as many different varieties, more or less rich in sugar, and which in reality were only the product of a degeneracy under the influence of a crossing more or less pronounced in each seed.

Such an experience for several years was disastrous, and it is upon this hybridizing of the sorghum cane and the broom cane that all the responsibility must be

thrown. Now that which is true in France should also occur in America, and the causes for the failure in the sugar cane must be the same in the two countries.

There is no doubt of the truth of M. Leplay's ideas in respect of the admixture of sorghum with broom corn, but such an admixture can be avoided, and if this were the only cause of deterioration we would have little to fear.

Horace Piper¹ says :

The natural cross-breeding of different varieties with those of inferior qualities is a very frequent cause of deterioration. This is often observed in gramineous and leguminous and curcubitaceous plants, which are raised annually from their seeds. All the varieties of maize are very liable to deteriorate in this way. Those of the *Sorghum saccharatum* intermix so freely that cultivators have found it almost impossible to obtain pure seeds. From the same cause it is extremely difficult to preserve any of the varieties of the melon pure for any considerable time.

No one can have any security of obtaining pure seeds unless they are planted many rods from all others, and the *perfect* flowers from which seeds are to be raised are covered with small tents of gauze of sufficient size to inclose each and protect it from insects. The judicious cross-breeding, however, of individuals of the same variety, when taken from a distance, will, as has before been observed, have a tendency to improve it.

The rapid deterioration of the juice of the cane when cut has been noticed by every one who has had anything to do with sorghum. This deterioration, however, is independent of the natural variations above mentioned.

The gradual failure of the sucrose in the juice is also noticed when there has been no admixture with broom corn, as pointed out by Mr. Leplay. This has been unmistakably illustrated at Rio Grande, N. J. The sugar in the amber cane there has been failing since the first until the year 1886, when the juice of this cane from several hundred acres was so poor that no attempt was made to convert it into sugar.

My own observations on this inconstancy of sorghum have been published more than once.

In speaking in a previous publication of the difficulties of successful sugar-making, I said :²

A careful study of the foregoing data will not fail to convince every investigator that the manufacture of sugar from sorghum has not yet proved financially successful.

The men who have put their money in these enterprises seem likely to lose it, and intending investors will carefully consider the facts herein set forth before making final arrangements. The expectations of the earlier advocates of the industry have not been met, and the predictions of enthusiastic prophets have not been verified. It would be unwise and unjust to conceal the fact that the future of the sorghum-sugar industry is somewhat doubtful. In the first place, the difficulties inherent in the plant itself have been constantly undervalued. The success of the industry has been based on the belief of the production of sorghum with high percentages of sucrose and small amounts of reducing sugar and other impurities.

But the universal experience of practical manufacturers shows that the average constitution of the sorghum-cane is far inferior to that just indicated. Taking the

¹ Ann. Report, U. S. Department of Agriculture, 1867, p. 315.

² Department of Agriculture, Division of Chemistry, Bull. No. 5, pp. 185, *et seq.*

mean of several seasons as a sure basis of computation, it can now be said that the juices of sorghum as they come from the mill do not contain over 10 per cent. of sucrose, while the percentage of other solids in solution is at least 4.

Another difficulty with which the industry has had to contend has been found in the crudeness and inefficiency of the machinery which has been in use.

Successful sugar-making depends more on the efficiency of the machinery used than almost any other kind of manufacturing. It is safe to say that should the sugar-makers of Europe attempt to make beet sugar with machinery as imperfect as that used in the sorghum-sugar manufacture the attempt would end in disastrous failure.

The working of sorghum juices will be found as difficult as those of beets, and true success can not be hoped for until the processes used for the one are as complete and scientific as for the other. It is not meant by this that the processes and machinery are to be identical.

The chemical as well as mechanical treatment of the two kinds of juice will doubtless differ in many respects. And this leads to the consideration of the third difficulty, viz, the chemical treatment of sorghum juice. It has taken nearly three-quarters of a century to develop the chemistry of the beet-sugar process, and even now the progress in this direction is great. The chemistry of the sorghum-sugar process is scarcely yet a science. It is only an imitation of what has been done in other fields of work. Sorghum will have to develop a chemistry of its own. This will not be the work of a day or a year, but it will be accomplished sooner or later.

Careful study of climate and soil, joined with experience, will gradually locate those areas most favorable to the growth of this plant and its manufacture.

This is an all-important point in the problem, and is now occupying seriously the attention of the thoughtful advocates of the sorghum-sugar industry. One thing is already clear, i. e., that the area of successful sorghum culture is not nearly so extensive as it was thought to be a few years ago. I would urge a further investigation in this direction as a work peculiarly within the province of the Department, and one which would prove of immense benefit to the country. Five million acres of land suitable to the purpose will produce all the sugar required for this country for several years to come. It is therefore certain that the sugar industry will be confined to the most favorable localities. If a thorough scientific study of all the soil and climatic conditions does not point out this region, bitter experience and the loss of hundreds of millions of dollars will gradually fix its boundaries. Last of all, the sorghum industry has suffered from the general depression which has been felt by the sugar industry of the entire world. Low prices have caused loss where every other condition has been favorable. It is hardly probable that the price of sugar will rise again to its maximum of the years passed. Only war, pestilence, or disaster would produce this effect. It is best, therefore, for the sugar-grower to accept the present price as final, and make his arrangements accordingly. But low prices will produce increased consumption, and thus even with a smaller profit the sugar-grower by increased production may find his business reasonably remunerative if not as enriching as before. The sorghum-sugar grower will be injured or benefited with the growers of other kinds of sugar by these economic forces. Hence there should be no enmity between the grower of the sorghum, the sugar-beet, and the sugar-cane, but all should work in harmony for the general good.

It is true that the present outlook is discouraging. But discouragement is not defeat. The time has now come for solid, energetic work. Science and practice must join improved agriculture, and altogether can accomplish what neither alone would ever be able to achieve. It is not wise to promise too much, but this Bureau would fall short of its duty were it either to suppress the discouraging reports of this industry or fail to recognize the possibility of its success. The future depends on the persistence and wisdom of the advocates of sorghum. The problem they have to solve is a most difficult one, but its solution is not impossible.

Again, in speaking of the necessity of systematic field experiments in securing a sorghum suitable for sugar making, I said :¹

Such a series of experiments carried on under uniform conditions over the whole country would do more in five years to determine these great agricultural problems than fifty years of spasmodic and disjointed work could accomplish.

Much of the success of the beet-sugar industry of Europe has been due to a wise selection and improvement of the seed, by which the sugar contents of the beet, in some instances, has been nearly doubled. There is no reason to doubt that a similar improvement (but not, perhaps, to the same extent) could be made in Northern cane. Such an improvement station could be established at small cost; but, to be effective, must be continued through, series of years. The seed of those canes showing the highest sugar content should be planted and the selection continued until a maximum of sugar is obtained. If in this way a variety of cane could be produced which would give an average result in analyses of only 2 per cent. uncrystallizable sugar and 10 per cent. of sucrose, it would prove of the greatest value to the country.

In another place, referring to the lessons which were taught by the Fort Scott experiments, I said :²

The chief thing to be accomplished is the production of a sorghum plant containing a reasonably constant percentage of crystallizable sugar.

Recently in a public address I said :³

It is easily seen from the foregoing figures that in four years I have never found a large field of sorghum, judged by the juice obtained, which was rich enough to make sugar economically.

On the other hand, intensive culture, like that given to a garden, has produced sorghum which, with the improved processes which have been introduced, would easily make 150 pounds of sugar per ton.

The sorghum enthusiast has been abroad in the land, and, in his wake, has closely followed the crank. Fairy tales of the richness of sorghum have been told everywhere, and have often obtained credence. Fictions of the imagination, and often, I am sorry to say, fictions without any imagination, have portrayed the glowing future of sorghum—a future full of triumph and glory. Sorghum has been extolled as the one great savior of the country, furnishing alike its bread, its sweets, its meats, and its drinks.

The hope for sorghum is not in new methods and new machinery; it is in the skill and patience of the agronomist.

Wise selection of seed, intensive culture, judicious fertilization—these are the factors that can make the sorghum sufficiently saccharificient.

Still more recently, having collected various data concerning the instability of sugar in sorghum, I presented them to the Indiana Academy of Sciences.

From this paper I make the following quotations :⁴

ON THE CAUSES OF THE VARIATIONS IN THE CONTENTS OF SUCROSE IN SORGHUM SACCCHARATUM.

For some years I have been investigating the *Sorghum saccharatum* in respect of its adaptability to the production of sugar.

During this time many difficulties have been encountered, and these troubles have all been overcome with one exception. The chief obstacles to successful sugar-making

¹ Department of Agriculture, Report 1883, pp. 443, 444.

² Department of Agriculture, Division of Chemistry, Bull. 14, p. 42.

³ Bulletin No. 2, Chemical Society of Washington, pp. 28, 29.

⁴ Botanical Gazette, Vol. XII, No. 3, pp. 54 et seq.

ing have been, first, unfavorable climatic conditions; second, imperfect methods of extracting the sugar; third, improper treatment of the extracted juice; fourth, variations and rapid changes in the sucrose of the juice. All of these problems have been successfully solved save the last. It is proper to say, however, that certain methods of cultivation and certain methods of selecting seeds tend to produce maximum contents of sucrose in the cane, and these methods are not yet fully developed. A proper conception of the variations to which the sucrose in sorghum is obnoxious can not be had unless we study briefly the method of its formation, how it is stored, and the physiological functions in which it takes part.

Vegetable physiologists have taught us that a carbohydrate can be formed by a certain retrogressive change in protoplasm, by which the cell envelope, in other words cellulose, is produced. The carbohydrates which appear in the embryo of a plant are developed at the expense of the stores of material in the seed. After the appearance of the chlorophyll cells in the plant the production of carbohydrates takes place with their aid, CO_2 being absorbed from the air and free oxygen being eliminated.

It would be easy to explain the production of carbohydrates by supposing that the chlorophyll cell exerted a reducing influence¹ on the CO_2 which, with the assimilation of water, produced, for instance, starch by the formula $6\text{CO}_2 + 5\text{H}_2\text{O} = \text{C}_6\text{H}_{10}\text{O}_5 + \text{O}_{12}$. In the vast majority of plants it is found, in corroboration of this supposition, that the volume of the oxygen set free is sensibly the same as the carbonic dioxide absorbed. The carbohydrate which is generally formed in the chlorophyll cells is starch. This starch is removed from the leaf, and it is supposed that the carbohydrates which are formed in all parts of the plant are derived from this original substance.

In point of fact, however, the production of organic matter in a plant does not probably take place in the simple manner above described. It is more likely that the presence of a nitrogenous body is necessary and this proteid itself is the active principle in the production of new organic matter, by a certain decomposition it suffers, with the help of carbonic dioxide and water. Nor is it by any means certain that starch is the only organic matter formed by the chlorophyll cells; in fact, it is known that oil is often the product of this constructive and destructive metabolism.

But it seems reasonable to suppose that the different sugars are as likely to be formed in the leaf of the plant as starch.² When we remember how easily starch is detected in most minute quantities, and how easily sugar is missed even when present in much larger quantities, we do not wonder that vegetable physiologists have supposed that starch is the first carbohydrate formed in the leaf, and that all the others are derived therefrom. The explanation, which is made of the translation of the starch from the point of its formation to the localities where it is stored, is as follows:

Take, for instance, the formation of starch in the germ of cereals. We are taught that the starch first formed in the leaves is changed into sugar, and in this soluble state carried through the plant until it reaches the seed. This sugar, reaching the point where the seed is forming, is changed to starch again by the amyloplast.

Let us subject this theory of the translation of starch to a brief examination. There are two only known methods by which starch can be converted into sugar, viz: First, by the action of certain acids, and second by the action of certain ferments. The conversion of starch into sugar by acids even at a high temperature and with the stronger acids is very slow. It is simply incredible that such a conversion can take place at the ordinary temperature in the leaf of a plant, and by reason of the action of the extremely dilute weak vegetable acids which the leaf contains. In the same

¹ It has lately been stated that this reduction is due to the action of electricity on the leaf—producing hydrogen—and this hydrogen is the active principle in the reduction of the carbonic dioxide. This statement appears to be purely theoretical.

² Meyer (*Botanische Zeitung*, 44, Nos. 5, 6, 7, 8) has lately shown that the leaf of the plant is incapable of forming starch out of sucrose, levulose, etc., and calls especial attention to the fact that starch may not be the original substance formed.

way it must be conceded that the opportunity for the action of a ferment in the leaf is extremely limited.¹ Such action requires time and much more favorable conditions than can be found in the living leaf. In any case if sugar be formed from starch in either of the ways indicated it could not be sucrose.

In fact the reducing sugar which is found in plants is seldom starch sugar, i. e., maltose or dextrose. This appears to be a fact which the vegetable physiologists have entirely ignored. The sugars of plants which reduce an alkaline copper solution are either derived from sucrose by inversion, or more probable are of independent formation. If they were derived from starch they would show dextro- if from sucrose, lævo- gyration. In point of fact they often show neither, as I long ago pointed out, when, in view of this optical inactivity, I proposed for them the name of anoptose. When they do show rotation, however, it is left-handed.

It seems to me that there is one fact that the physiologists forget, viz, that starch is not always insoluble. In my examinations of sorghum juices I have never failed to find soluble starch when I looked for it.² The existence of bodies when first formed in the soluble state, which when once made solid become insoluble, is not unknown. Certain forms of silica are illustrations of this. It seems much more reasonable to suppose that in the case of the sorghum, for instance, the starch which appears in the seed is partly transferred directly from the soluble nascent state to the seat of its final deposition. This, indeed, is hardly a theory in the light of the fact mentioned above—that the sap of the plant always contains soluble starch.

It is far more simple to suppose that the sucrose which we find in sorghum is produced directly by the decomposition of protoplasm in presence of carbonic acid, provoked by the katalytic action of the chlorophyll cell. At any rate there is no sort of evidence that it is ever made from starch, and no physiologist has ever invented any hypothetical saccharoplast to account for such a transformation.

This subject of the origin of sucrose is of great interest; but I have not yet finished my experimental studies of it, and so will not pursue it further at present.

The question now arises is the sucrose of sorghum a plastic material, reserve material, or waste? In respect of plastic material it is sufficient to call attention to the fact that the development of sucrose does not begin in the plant until it is far on the road to maturity. To this it may be objected that its accumulation does not begin until this period, and that what is formed earlier in its history is a really plastic material used in the development of other tissues. Had I time I might show, I think, conclusively, that the presence of the sucrose as a plastic material is not probable. Is it a reserve material? The sucrose which is deposited in the seeds of plants, in tubers like the sugar-beet, and in sugar-cane, doubtless is a true reserve material, and by its decomposition helps the growth of the succeeding plant. But the sucrose in sorghum seems to have no such function. It can in no way aid the incipient growth of the next plant, for that plant grows from a seed. As far as any use in the economy of the plant is concerned, it appears to be absolutely worthless. It is true that in the case of "suckering," the sucrose in the cane may suffer loss, but "suckering" is not always a natural growth; it is adventitious and is always detrimental to the proper maturity of a plant.

It seems, therefore, that the sucrose in sorghum is purely a waste material—as much so as an alkaloid or a resin.

In the cases where sucrose is a true reserve material, as in seeds, in tubers, and in sugar-cane, we find there is no tendency for it to disappear until the needs of the new plant require it. The sucrose remains, for instance, unchanged in the sugar-beet until the new growth begins. The same is true in a higher degree of the sucrose in seeds. The fact, therefore, that in sorghum all traces of sucrose may disappear in a few days shows that its office is radically different.

¹ The ferment which acts on the starch has been studied by Brasse and Schimper (Bied. Centralblatt, vol. 14, p. 169, vol. 15, pp. 310 and 473). It is called *amylase*.

² That is a body in solution which gives a blue color with iodine.

As a result of my investigations I will say that the development of sucrose in sorghum is an accidental function, or rather an adventitious function. It goes on usually *pari passu* with the formation of the starch in the grain and the content of sucrose in the plant, and its quantity is at a maximum at the time the starch formation is completed. In the sugar-cane the sucrose appears to be not only reserve, but also plastic material. In the upper part of the cane the content of sucrose is much less than in the lower, showing that in the region of most active growth the sucrose may suffer decomposition and help in the formation of proteid. (I wish to add here that the only way in which the plant can use sucrose for the formation of other bodies or for working it into living tissues is by thus getting it into protoplasm.) On the other hand, the content of sucrose in sorghum is sensibly the same in all parts of the cane, being just as great at the top near the place of most rapid starch storage, as it is near the base. It is not strange, therefore, if it be true that the production of sucrose is only the expression of the exuberant vitality of the leaf of the sorghum, that the greatest variations should be met with the content of sucrose. These variations are not confined to different varieties or to different fields, but are found in the same variety in different canes growing in the same hill, and which, therefore, have been subjected to precisely the same conditions of culture and weather.

In ten successive analyses of sugar-beets made two years ago, I found no greater variation than 1 per cent. in sucrose. The same was true of ten successive analyses of sugar-canes I made last month, November, 1886. On the other hand, any ten successive analyses of sorghum-canes, made last October, will show a variation of 6 per cent.

I have not the time here to cite all the instances I have noticed which illustrate the principles set forth above. They number hundreds. Without a record of these analyses, however, the fact clearly appears that the chief cause of variation is found in the accidental or adventitious nature of the formation of the sucrose; in other words, its independence of the life history of the plant. When, however, the sucrose has once been formed, as in a mature cane, it is subject to sudden variations. Sudden changes in the weather, severe frosts, followed by warm weather, or simply standing dead ripe, often cause a rapid disappearance of the sucrose. It is first converted into invert sugar and this quickly disappears by fermentation.

When the canes have been cut also, if they be expressed at a temperature of a warm September day, the sucrose is rapidly inverted. This inversion is not due to the action of the acids which the sap contains, but is produced by a special ferment, probably *invertin*, or some similar substance.¹

These variations in the content of sucrose are, as I intimated at the beginning, the chief obstacles now in the way of the successful introduction of a sorghum-sugar industry into this country. The last one is easily avoided by promptly working the cane as soon as it is cut. The first one can only be overcome by the scientific agronomist, aided by the best practical botany and chemistry.

Since writing the above I have received the *Revue Scientifique*, of February 5, 1887, containing a notice of the observations of Girard on the production of carbohydrates in plants. This author definitely confirms my statements in respect of the independent formation of sucrose in leaves. The reviewer says:

"Les expériences de M. A. Girard mettent hors de doute que les limbes fabriquent alors des saccharoses et des sucres réducteurs."

M. Girard shows the possibility of leaves developing starch from sucrose, but there appears to be no evidence that the reverse of this operation takes place.

YIELD PER ACRE.

In the experiments of the New Jersey station we have already seen the theoretical yield of sugar per acre. It is a matter of considerable

¹ Ducloux, *Compt. rend.*, 103, p. 881, has shown that sunlight is capable of invertin solution of sucrose.

importance to know what the average yield of sorghum in clean stalks per acre is. Weber and Scovell¹ report yield of clean cane, equal to 15,766 pounds or 7.88 tons per acre. Professor Henry² gives the following as the yield of cane per acre :

	Pounds.
First plot	30,348
Second plot.....	23,550

In 1882 Henry found the following as a mean yield in clean cane of fifteen plots calculated to one acre:³ Mean for fifteen experiments, 14,300 pounds=7.15 tons.

The yield per acre for the field crop⁴ in the several fields was as follows :

First field	20,906 pounds = 10.45 tons.
Second field.....	14,487 pounds = 7.24 tons.
Third field	13,688 pounds = 6.84 tons.

In the field trial of cane by the Department at Washington in 1881 the average yield from 94 acres was 5,000 pounds⁵=2.5 tons.

The mean weight of clean cane per acre as determined at Champaign, Ill., in 1882, is seen from the following data.⁶

Number acres.....	244.59
Number tons.....	2,882.75
Tons per acre.....	9.33=18,660 pounds.

The average yield of 6.85 acres at the Wisconsin agricultural farm in 1882 was 16,200 pounds per acre, equal to 8.1 tons.

Nelson Maltby obtained (mean of 17.5 acres) 9.5 tons per acre, equal to 19,000 pounds.⁷

Drummond Brothers report an average of 26.5 acres, at 9.17 tons, equal to 18,340 pounds.⁸

A. J. Decker⁹ reports average yield of 45 acres at 6 tons, equal to 12,000 pounds.

William Frazier¹⁰ states yield for 45 acres averaged 6 tons per acre, equal to 12,000 pounds.

A. L. Talcott¹¹ estimates yield per acre at 9.6 tons (226 acres), equal to 19,200 pounds.

Belcher and Schwarz¹² report yield for 191 acres at 3 tons per acre, 6,000 pounds.

¹ Transactions Department of Agriculture, Illinois, 1881, p. 501.

² Experiments in Amber cane, 1881, p. 14.

³ Second Annual Report, Amber cane, p. 8.

⁴ *Op. cit.*, p. 14.

⁵ Encouragement to Sorghum, p. 3.

⁶ *Op. cit.*, p. 13.

⁷ *Op. cit.*, p. 27.

⁸ *Op. cit.*, p. 28.

⁹ *Op. cit.*, p. 35.

¹⁰ *Op. cit.*, p. 37.

¹¹ *Op. cit.*, p. 46.

¹² *Op. cit.*, p. 33.

Bozarth¹ from 85 acres reports a yield of 8.1 tons per acre, equal to 16,206 pounds.

In a field of 64 acres grown by the Department of Agriculture near Washington, in 1883, the yield was 746,250 pounds of clean cane, or 11,662 pounds per acre, equal to 5.83 tons.

At Rio Grande, according to the report of Professor Cook already cited,² it is shown that the average yield of that plantation for five years (about 1,000 acres per annum) was only 7.7 tons of unstripped and untopped canes, or of clean cane about 6 tons, equal to 12,000 pounds per acre.

TONNAGE PER ACRE DETERMINED BY THE EXPERIMENTS OF THE
NEW JERSEY AGRICULTURAL STATION.³

In 1881 the average yield at the New Jersey experiment station⁴ was 4.84 tons, equal to 9,741 pounds per acre.

In 1882, in fall-plowed land, the mean yield in sixteen experimental plots was 8.45 tons, equal to 17,110 pounds⁵ per acre.

For the spring-plowed land the numbers are 9.84 tons per acre, equal to 19,680 pounds.⁶

For 1883 the mean yield of sixteen experimental plots was 14.4 tons, equal to 28,851 pounds per acre.⁷

In 1884 the mean yield of sixteen experiments was 10.30 tons, equal to 20,601 pounds per acre.⁸

In 1885 the mean yield of sixteen plots was 12.48 tons, equal to 24,965 pounds per acre.

In 1886⁹ the mean weight of cane on fourteen fertilized plots calculated to 1 acre was of clean cane 10,443 pounds, equal to 5.22 tons.

I believe a perfectly fair average of the yield per acre of sorghum, taking into consideration all seasons and methods of culture and fertilizing, will be found by the investigation of the foregoing means.

¹*Op. cit.*, p. 58.

²Sixth Ann. Report New Jersey Agricultural Experiment Station, p. 119.

³Ann. reports of station.

⁴*Op. cit.*, 1881, p. 45.

⁵*Op. cit.*, 1882, p. 64.

⁶*Op. cit.*, p. 65.

⁷*Op. cit.*, 1883, p. 70.

⁸*Op. cit.*, 1884, p. 84.

⁹*Op. cit.*, 1886, p. 151.

Summary.

Authority.	Yield per acre.
	<i>Tons.</i>
Weber and Scovell	7.88
Henry and Swenson	15.17
Henry	11.77
	7.15
	10.45
	7.24
	6.81
Harvey	2.50
Weber and Scovell	9.33
Henry and Swenson	8.10
Maltby	9.50
Drammond Bros	9.17
Decker	6.00
Frazier	6.00
Talcott	9.50
Belcher and Schwartz	3.00
Bozarth	8.10
Wiley	5.81
Hughes and Cook	6.00
	6.00
	6.00
	6.00
	6.00
Cook	4.87
	8.45
	9.84
	14.40
	10.20
	12.48
	5.22
General average per acre	7.97

We may, therefore, place the average crop of topped and stripped cane in round numbers at 8 tons per acre.

Practical farmers, chemists, and manufacturers have long recognized the imperative necessity of producing a better raw material for sorghum sugar-making, but many of those who have gone into the business have not been impressed with such a necessity.

In many of our newspapers, in some official documents, and in the report of the Academy of Sciences, which has already been quoted, sorghum has been represented as the equal of Louisiana sugar-cane, and therefore the great inferiority of it to that sugar plant has been first revealed by the crash of financial failure.

Among the methods which have been tried for increasing the sucrose in sorghum I will cite the

EFFECT OF REMOVAL OF THE SEED HEADS.

The question of the formation of sucrose in the sorghum cane has already been discussed.

Formerly, when it was considered that the starch was derived from the sucrose, it was supposed *a priori* that the removal of the panicle, thus preventing the formation of starch, would tend to increase the percentage of sucrose in the juice.

It is stated in Hyde's book¹ that—

¹ The Chinese Sugar-Cane, Hyde, pp. 23, 24.

The ripeness of the seeds does not appear much to lessen the production of sugar, at least in the climate near Paris, but in other countries where it matures when the weather is still warm the effect may be different. According to the report of M. de Beauregard, addressed to the "Comice de Toulon," the ripening of the sorgho in that latitude had no unfavorable effect; and he considers the seeds and the sugar as two products to be conjointly obtained. On the other hand, Mr. Wray says the Zulu-Kaffirs are in the habit of pulling off the panicles of the plant the moment they appear, in order to augment the quantity of saccharine matter in the stalks.

Mr. Leonard Wray¹ makes the same statement. In the direction for making sugar from sorghum printed in "The Working Farmer," and quoted in the book of Mr. Stansbury,² occurs the following sentence:

When the grower intends to make sugar, he should pinch off the seed heads before they are fully formed, or indeed as soon as they appear, thus causing the plant to give a larger yield of stronger juice.

In 1882 and 1883 experiments were made by Prof. H. A. Weber and Prof. M. A. Scovell, at Champaign, Ill., to determine the effect of the removal of the seed heads. Following is Professor Weber's report:³

The first experiment in topping cane was made in the season of 1882. It was suggested by the theory that the starch, which forms about 63 per cent. of the weight of the seed, could, by removing the top in time, be retained in the stalk in the form of cane sugar. The experiments in this direction fully proved the correctness of this theory. In the first experiment a portion of the heads was removed from a plat of Amber cane soon after they made their appearance and before there was any visible formation of seed. When the remaining cane had reached the hard-dough stage comparative analyses were made, with the following results:

	Topped.	Untopped.
Density, Baumé.....	9.5	8.1
Cane sugar, per cent. . .	12.62	7.80
Grape sugar.... do.....	2.58	4.80

In the season of 1883 two more experiments were made in this direction. In the first one, a field of Kansas orange cane was chosen. Two rows lying side by side and of uniform growth were selected. One was topped as soon as the heads appeared. The first comparative analyses were made on September 19, when the upper half of the seed heads was in the hardening dough. The results are as follows:

	Topped.	Untopped.
Density, Baumé.....	10.8	9.8
Cane sugar, per cent. . .	14.4	11.83
Grape sugar.... do.....	4.01	3.89

Two more comparative analyses of the same rows were made on October 2, after the seed was fully ripe.

¹ Agricultural Report 1854, p. 222.

² Stansbury, Chinese Sugar-Cane, p. 35.

³ Department of Agriculture, Division of Chemistry, Bull. No. 5, pp. 145, 146.

The following table shows the results :

	Topped.	Untopped.
Density, Baumé.....	13.3	9.4
Cane sugar, per cent...	14.82	11.53
Grape sugar... do.....	2.82	3.53

The last test was made with a plat of Indian cane. The topping was done August 23, three days after the heads began to appear.

The comparative analyses were made October 6. At this date the seeds were perfectly ripe, and would drop from the head when shaken.

The results are given in the following table :

	Topped.	Untopped.
Density, Baumé.....	10.2	8.3
Cane sugar, per cent...	13.04	10.06
Grape sugar... do.....	1.54	2.46

These results show an increase of over 3 per cent. of cane sugar in favor of the topped cane.

Dr. Collier also was led to investigate the same subject.¹

Two sets of analyses were made. In the first set of ninety-six pairs of analyses the results are as follows :

In the juice.

	Seed removed.	Seed on.
	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	12.66	9.96
Glucose.....	.97	1.40
Total solids.....	16.61	14.31

In the second set of forty-two pairs of analyses the results were as follows :

	Seed removed.	Seed on.
	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	11.34	12.08
Glucose.....	1.21	1.08
Total solids.....	15.53	15.89

Dr. Collier makes the following observations on the results of these analyses :²

The practical conclusions from these results are, that there is no incompatibility between the maximum crop of ripe seed possible, and the maximum content of sugar in the juice of the stalks; and that, owing to the more rapid development of the cane

¹ Collier's Sorghum, pp. 138 and 241; Special Report, pp. 18 *et seq.*

² *Op. cit.*, p. 140.

from which the seed has been removed, the time necessary from planting to the maturity of the crop would be shortened from seven to ten days for each of the varieties, if the seed was removed early.

In 1884 I made a large number of experiments in the study of the effect of topping the canes.¹

After having compared all the analyses the following conclusions were reached :²

The effect of cutting off the young heads in increasing the per cent. of sucrose was not as marked as had been expected, being a little less than .3 per cent.

Experiments on a much larger scale were made at Ottawa, Kans., in 1885, and these trials confirmed in every respect the results obtained at Washington the preceding years.

Following are the data :³

Means of ten analyses.

	Sucrose.	Glucose.	Total solids.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Topped and suckered canes....	12.45	1.99	17.26
Topped canes, not suckered...	12.46	2.09	17.81
Natural canes.....	12.15	2.06	16.77

From the above results it is seen that no appreciable increase of sucrose is obtained by topping and suckering the canes.

Even had experiments shown a notable increase in sucrose in the juices of those canes from which the seed heads had been removed the practical difficulties attending the process would prevent it from ever becoming more than an experimental study.

I think, therefore, we may at once dismiss all expectations of ever increasing the value of sorghum as a sugar producer by preventing the maturation of the seed.

THE FORT SCOTT EXPERIMENTS.

For the first time in the history of sorghum sugar making an opportunity was presented at Fort Scott in 1886 to try under identical conditions the relative merits of Louisiana sugar cane and Kansas sorghum as sugar-producing plants.

The light which this trial has thrown on the vexed problem has served to illuminate many points which were in obscurity. A candid study of the results of the experiments will set at rest all doubts in respect of the relative merits of these two sacchariferous plants.

In the Chicago Journal of Commerce of July 6, 1887, Dr. Collier makes a comparison of the analyses of juices of sorghum and sugar canes, which he submits as the teachings of years of experiment.

¹ Department of Agriculture, Div. of Chemistry, Bull. No. 5, pp. 139 *et seq.*

² *Op. cit.*, pp. 144, 145.

³ Bull. No. 6, p. 16.

From these analyses he draws the following conclusions:

The average of the above (including two hundred and two analyses of sugar-cane juices grown on different plantations and in different years, and of three hundred and thirty-one analyses of many varieties of sorghum juices also grown in different years) gives for each ton of sugar cane 225 pounds total sugar, of which 179 pounds are theoretically available, and for each ton of sorghum cane a total of 261 pounds of sugar, of which 199 pounds are available.

In respect of the quality of the crop of sorghum at Fort Scott the same writer in the Journal of Commerce of the date mentioned, after quoting the results of a single analysis, makes the following observations:

Now, the above shows in each ton of cane 238½ pounds total sugar, of which 169 pounds were available.

Such was the average crop of cane according to the very best, and indeed the only method by which its value could be ascertained.

It is thus seen that it has been claimed that the sorghum crop at Fort Scott was not only equal to Louisiana cane, but, in fact, far superior to it in its sugar-making qualities.

The same authority says: ¹

The next question which arises is most naturally this: Granting that this sugar is found in the crop of cane, can it be recovered by processes similar to those employed on the sugar-cane plantations of the South or the best sugar factories of Europe? I reply with a decided yes to this most important practical question.

In the light of these statements the value of the actual comparison is greatly increased.

ABSTRACT OF EXPERIMENTS WITH SORGHUM AT FORT SCOTT, KANS., IN 1886.²

Mean composition of juices, seventy analyses, expressed from small quantities of sorghum canes during the entire season: ³

	Per cent.
Sucrose.....	9.34
Glucose.....	4.10
Total solids.....	16.94
Purity co-efficient.....	55.14

The small samples of cane above mentioned were taken in such a way as to represent as nearly as possible the general character of cane entering the mill. It is idle to claim, however, that in nearly 3,000 tons of cane, varying in such a marked manner as has already been set forth, such a selection of samples could accurately represent the whole. They might give results better or worse than the average. Which of these was the case with the above samples will appear by studying closely the following data:

SAMPLES COLLECTED FROM CHIPS ENTERING EACH CELL AND AFTER MIXING PASSED THROUGH SMALL MILL.

Such samples represent much more accurately than those just studied the average composition of the canes entering into manufacture.

¹ Chicago Journal of Commerce, November 17, 1886.

² Department of Agriculture, Div. of Chemistry, Bull. No. 14.

³ *Op. cit.*, pp. 14, 15.

They were taken on twelve different days, from October 15 to 27, and each sample represents the mean composition of 10 tons of cane. The means of the twelve samples are as follows :¹

In the juice.

	Per cent.
Sucrose	7.28
Glucose	3.74
Total solids	14.80
Purity co-efficient	49.00

MEAN COMPOSITION OF THE DIFFUSION JUICES FOR THE WHOLE SEASON.

Following are the means of seventy-six analyses² extending over the whole season. The samples were taken (a measured quantity) from each cell when discharged. After ten samples were collected and mixed the analysis was made. The results of the analyses are, therefore, a true index of the diffusion juices for the entire season :³

	Per cent.
Sucrose	5.10
Glucose	3.07
Total solids	11.47
Purity co-efficient	44.4

There is one point in the above data to which I desire to expressly call attention. The juice which was actually worked for sugar at Fort Scott was the *diffusion juice*, of which the mean composition is given above. This juice, according to the methods of estimating its value in common use, not only would not yield crystallizable sugar, but, on the other hand, could have had a large quantity of pure sugar added to it before any could be obtained in the ordinary process of manufacturing.

The above is the actual character of the juices which Dr. Collier has stated had in each ton "238.5 pounds sugar, of which 169 pounds were available."

We now turn for comparison to the data obtained with identically the same processes employed at Fort Scott to make sugar from sugar cane.

The canes on which these trials were made were cut in Louisiana October 25 to 30, and subjected to diffusion at Fort Scott, November 6 and 7, 1886.

MEAN COMPOSITION OF THE JUICES IN THE CANE.

Samples of chips were taken from each cell until twelve were filled. These samples were passed through the small mill and the analyses made in the mixed juices.

Five sets of analyses were made, giving the mean composition of seventy-two tons of chips.

¹ *Op. cit.*, p. 17.

² *Op. cit.*, pp. 18, 19.

Following are the means of the results:

<i>In juice.</i>	
	Per cent.
Sucrose	10.62
Glucose	1.78
Total solids	14.38
Purity co-efficient	73.8

COMPOSITION OF DIFFUSION JUICES FROM ABOVE CANES.

The samples were taken by withdrawing a measured quantity from each of the twelve cells and thoroughly mixing. Six sets of analyses were made.

Following are the means:

	Per cent.
Sucrose	7.16
Glucose	1.23
Total solids	9.86
Purity	72.6

In this connection it must be remembered, too, that the mean temperature used in the diffusion of sorghum chips was 70° C., while for sugar cane the diffusion took place at 90°. Therefore, a much greater inversion would be expected with the former than with the latter.

In point of fact, it has been clearly established that the sucrose in ripe and fresh sorghum canes undergoes no appreciable inversion during the process of diffusion at 70°, if that process is not delayed by faulty machinery or accidents. When inversion in the battery does take place, it is due to the fact that chips are used which are not in a fit state for sugar making, or by reason of some delay in the process.

Without discussing further the details of the experiments with sugar-cane, I desire to call your attention to the following points:

(1) Sorghum-canes manufactured at Fort Scott in 1886 gave a yield of 21.6 pounds sugar per ton.

(2) Louisiana sugar-cane, manufactured at the same place, by identically the same processes, and under identical conditions, save that the temperature in diffusion was 20° higher, gave 144 pounds sugar per ton.

The sorghum-cane, therefore, grown at Fort Scott was nearly seven times less valuable for sugar making than the sugar-cane. I am fully convinced of the fact, however, that had the machinery at Fort Scott in 1886 been perfect, so that the sorghum could have been promptly worked at maturity, the quantity of sugar it made would have been greatly increased. This fact I have emphasized in Bulletin No. 14.

It will be of interest in closing this brief review of our present knowledge concerning sorghum and sugar cane, to add to the summary given the results of the final experiments recorded in Bulletin No. 17. In the summary of the data for Louisiana this has already been done.

The mean composition of sorghum juices used for manufacturing sugar on a large scale up to 1887 and the means of the two stations at Rio Grande and Fort Scott for 1887 are as follows:

	Up to 1887.	Rio Grande, 1887.	Fort Scott, 1887.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Sucrose.....	8.54	8.98	9.54
Reducing sugar.....	4.59	8.24	8.40
Total solids.....	15.19	14.62	16.14
Purity.....	56.22	64.05	59.11

It will be seen that the cane both at Rio Grande and Fort Scott was slightly better than the average of the recorded analyses up to that time. I see no reason to doubt, however, the possibility of producing in a few years a sorghum-cane, the purity of whose juice will average higher even than that at Rio Grande.

I am not one of those, however, who claim for sorghum a position above the sugar-cane, either at present or remotely. All such claims are based either purposely on a few selected analyses, or ignorantly on partial evidence, or on no scientific evidence whatever.

The work which has been done under my supervision has had a double purpose: (1) To determine the true average sugar content of sorghum when grown on a commercial scale; and, (2) to devise the best methods of securing the sugar in merchantable form.

I have not hesitated to state the facts as they were disclosed during the progress of the work, nor have I knowingly concealed any result which has had any apparent relation to the problem, whether of a favorable or unfavorable nature.

In conclusion, I will say that I have written this bulletin to bring into convenient shape for reference all the information which I have been able to collect concerning the sugar industry of this country.

INDEX.

A.

	Page.
Analyses made by Division of Chemistry in 1883	65
Antisell, Dr. Thomas, analyses by	61
Armsby, Dr. H. B., analyses by	78

B.

Bagasse, analyses of	53
composition of.....	54
Blades and stalks, composition of juice in	65
Bozarth, C., report of	97

C.

Cane, sorghum, various yields per acre of.....	118
yield per acre	117
Canes from different parts of Wisconsin, analyses of	75
frosted, analyses of	65
selected, analyses of juices of.....	6
sorghum, analyses of, by Dr. C. M. Wetherill.....	59
stripped and unstripped, analyses of	68
Chips, samples of, collected from each cell and after mixing passed through a small mill	124
Clarification, effect of diffusion, methods of.....	57
Collier, Dr. Peter, analyses by.....	61
effect of removing seed heads.....	122
Fort Scott experiments.....	123
sorghum crop at Fort Scott	124

D.

Decker, A. J., report of	95
Diffusion experiments at Ottawa, Kans., 1885	69
chemical control of.....	38
juices at Fort Scott, mean composition of	125
for the season of 1886, mean composition of	72
run, first.....	38
second	39
third	40
fourth	41
fifth	42
runs, summary of results by	43
Drummond Brothers, report of.....	95

E.

	Page.
Experiments at Fort Scott, comments of Dr. Collier on	123
during 1888, analyses in	71
for which an award of \$1,200 was made by the Commissioner of Agriculture	93

F

Fallyer, Prof. G. H., report of	88
Fake, N. J., analytical work by	29
Fort Scott, analytical work at, season of 1887	5
instructions sent to	5
work at, additional notes on	11
Frazier, William, report of	96

G.

Goessmann, Dr. C. A., analyses by	73
experiments in the manufacture of sorghum sugar by	89

H.

Harvey, Mr. J. H., report of	99
Helena, Wis., analyses made by Department at	69
Henry, Prof. W. A., analyses by	88
Hilgard, Professor, analyses by	74

I.

Illinois Industrial University, experiments at, in 1880	90
---	----

J.

Jackson, C. T., analyses by	72
Jefferson Sugar Company, report of	96
Juice, discussion of the composition of, at Fort Scott	126
from exhausted chips and corresponding diffusion juices, table of glu- cose and sucrose in	10
Juices, comparative samples of raw, clarified, and filtered, table of analyses of.	33
and clarified, table of analyses of	32
defecated, table of analyses of	71
diffusion, for the season of 1886, mean composition of	72
tables of analyses of	9, 22
employed in manufacturing, analyses of	106
exhausted chip, table of analyses of	23
from diffusion chips, table of analyses of	20
hand mill, analyses of	109
in the cane at Fort Scott, mean composition of	125

L.

Lime-kiln and bagasse chimney, carbonic dioxide in gases from	57
Lovering, Joseph S., experiments by	88
Lynch, Mr. Peter, statement of	99

M.

Magnolia, special analytical work at	49
summary of data for four years at	46
work at	29
Maltby, Nelson, report of	95

	Page.
Masse cuites, analyses of	13
first, table of analyses of.....	35
sugars, and molasses from diffusion runs, analyses of.....	43, 44
table of analyses of.....	26
Mill juices at Magnolia	29
table of analyses of.....	30
from exhausted chips, table of analyses of.....	10
fresh chips, table of analyses of.....	8
whole canes, table of analyses of.....	7
single and double polarizations of.....	50
Molasses, analyses of, sent by W. J. Thompson	51
effect of treatment of, with superphosphate of lime and alumina....	56
first, analyses of.....	36
from first sugars, table of analyses of.....	14
seconds, table of analyses of.....	16
second, analyses of.....	37
table of analyses of.....	27
single and double polarizations of.....	51
Monselise, Prof. Guilio, analyses by	77
N.	
New Jersey Agricultural Station, analytical data from the experiments at	82
O.	
Oak Hill, experiments made at, in 1857	87
Oak Hill Refining Company, report of	97
P.	
Polarization, comparison of direct and indirect	49
R.	
Rio Grande, N. J., work at	20
S.	
Seed heads, effect of removal of	120
removal of, experiments by Dr. Collier in.....	122
Sirups at Magnolia, table of analyses of	34
single and double polarization of.....	50
tables of analyses of.....	12, 25
Sorghum, abstract of experiments with, at Fort Scott, Kans.	124
as a sugar-producing plant, data relating to.....	59
analyses of, by Henry Erni.....	60
at Pruden, Miss.....	77
cane, discussion of cross-breeding of.....	112
the deterioration of.....	112
the variation of, by Hippolyte Leplay.....	110
yield per ton of.....	15
experiments in the culture of, at Algiers.....	110
with, at Modena, Italy.....	77
grown at Hutchinson, Kans., analyses of.....	79
juice, comparison of the composition of, at Rio Grande and Fort Scott in 1857.....	127
juices manufactured into sugar, means of analyses of.....	107
mean analyses of.....	107
nitrogenous bodies in.....	28
total solids in.....	16

Compliments of

Norman J. Colman,

Commissioner of Agriculture

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF CHEMISTRY.

BULLETIN

No. 19.

METHODS OF ANALYSIS

OF

COMMERCIAL FERTILIZERS, CATTLE FOODS,

DAIRY PRODUCTS, SUGAR, AND FERMENTED LIQUORS,

ADOPTED AT THE

FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL
AGRICULTURAL CHEMISTS, HELD AT THE U. S. DEPART-
MENT OF AGRICULTURE AUGUST 9 AND 10, 1888.

EDITED BY

CLIFFORD RICHARDSON,
SECRETARY OF THE ASSOCIATION.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.

1888.

7717—Bull 19

LETTERS OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF CHEMISTRY,
Washington, D. C., September 4, 1888.

DEAR SIR: Complying with your invitation the Association of Official Agricultural Chemists met in the rooms of the Chemical Division August 9 and 10 this year. I have the honor to submit for your approval, with a view to publication as Bulletin 19 of this division, the official proceedings of that meeting, as attested by the inclosed letter from the secretary.

Respectfully,

H. W. WILEY,
Chemist.

Hon. N. J. COLMAN,
Commissioner of Agriculture.

WASHINGTON, *August 31, 1888.*

DEAR SIR: I have the honor to hand you herewith, for publication, an abstract of the proceedings of the fifth annual convention of the Association of Official Agricultural Chemists, together with the methods adopted for official use during the ensuing year for the analysis of commercial fertilizers, cattle foods, dairy products, sugar and sugar products, and fermented liquors.

To this has been appended a list of the reporters upon the different subjects for 1888-'89, of the officers of the association, and the constitution as amended.

The demand for information of the nature given in the proceedings is rapidly increasing, and the methods of the association are almost universally adopted in this country as standards.

Very respectfully,

CLIFFORD RICHARDSON,
Secretary, Association of Official Agricultural Chemists.

Dr. H. W. WILEY,
Chemist, etc.

UNIFORM METHODS FOR THE ANALYSIS OF FERTILIZERS, CATTLE FOODS, DAIRY PRODUCTS, SUGAR, AND FERMENTED LIQUORS.

PROCEEDINGS OF THE FIFTH ANNUAL CONVENTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, HELD AT WASHINGTON, AUGUST 9 AND 10, 1888.

MORNING SESSION, THURSDAY.

In accordance with the call of the secretary, the Association met in the library of the Department of Agriculture at 10 o'clock, the president, Mr. P. E. Chazal, in the chair.

The following members and "others interested in the objects of the Association" were present:

The president, Mr. P. E. Chazal, State chemist of South Carolina.

The vice-president, Dr. W. J. Gascoyne, of Baltimore.

The secretary, Mr. Clifford Richardson, of Washington, D. C.

Of the executive committee, Prof. John A. Meyers, of the West Virginia Agricultural Experiment Station.

Dr. H. W. Wiley, Washington, D. C.; Dr. C. A. Crampton, Washington, D. C.; Prof. William C. Stubbs, of Louisiana; Prof. E. A. von Schweinitz, of Salem, N. C.; Prof. Richard H. Gaines, of Richmond, Va.; Prof. William Frear, of State College, Pa.; Prof. H. J. Patterson, of Agricultural College, Md.; Prof. W. L. Hutchinson, of Agricultural College, Miss.; Prof. G. S. Fellows, of Washington, D. C.; Prof. E. B. Voorhees, of New Brunswick, N. J.; Mr. B. B. Ross, of Louisiana; Mr. Edgar Richards, of Washington, D. C.; Prof. M. A. Scovell, of Lexington, Ky.; Prof. E. H. Farrington, of Hanover, N. H.; Prof. C. W. Dabney, jr., of Knoxville, Tenn.; Prof. F. A. Holton, of Iowa City, Iowa; Mr. W. M. Saunders, of Providence, R. I.; Prof. H. C. White, of Athens, Ga.; Messrs. Knorr, Fake, Edson, and Dugan, of the U. S. Department of Agriculture.

Letters of regret were read from Dr. E. H. Jenkins, of Connecticut; Dr. G. C. Caldwell, of New York; Prof. George F. Cook, of New Jersey, and others.

The president, in calling the meeting to order, said that he would omit the usual address, as there was a desire to proceed at once to business, with the view of accomplishing the objects of the convention in as short a time as possible.

On a call for reports of committees, Mr. Richardson, in the absence of the chairman, presented the report of the Committee on Cattle Foods, as follows:

REPORT OF THE COMMITTEE ON CATTLE FOODS.

Your committee offer the following report on the work done during the year on the analysis of fodders and feeding stuffs:

Only six out of a dozen or more who undertook to make these analyses for the committee were able to do the work. In many cases so much time was consumed, in the latter part of the year, in the reorganization of the experiment stations, under the provisions of the Hatch bill, that too little was left for these deferred analyses. Moreover, some of the reports were received so late that no copy of the results sent by all the analysts could be sent to each of the parties doing the work, so that if any one so desired he might repeat the analyses with a view to some possible explanation of the discrepancies that occur.

There is no reason to doubt that these analyses, the results of which are given below, were made by one method and with careful attention to the directions given by your committee, and by analysts at least quite up to the average, in respect to skill and special training, of those who commonly do this sort of work at the experiment stations, and yet there are some very serious differences in the results.

It appears to your committee, therefore, that there is occasion for more work on this line, and it may reasonably be hoped that with the large number of experiment stations in operation now a much larger number of participants in this work can be found who can undertake the analyses and complete them in season for a more careful preparation of the report by the committee having it in charge.

Your committee would, therefore, suggest that, if the work is continued, the samples, three in number, as hitherto, be sent out before the middle of October; that the analyses be made strictly according to one scheme, without, however, excluding alternate methods that any one may wish to try in addition to those prescribed by the committee; that the time for receiving the reports be limited to February 1; that a tabulated copy of all results received be sent out within two weeks thereafter to each contributor, and that then a limited time be allowed, say one month, for any revision of his work that he may wish to make.

As one illustration of such possible revision, the uniformly higher results reported in the first line of each list below, on nitrogen and protein, may be due to some fault in the standardization of the solutions used for the titration of the distilled ammonia solutions. Additional illustrations may occur to others on inspection of the figures.

Only one report was received on any alternate methods. At the Connecticut station all the samples were analyzed also by the method in common use there; but no description of the methods followed accompanied the results. These results given for the air-dried substance were in very many of the cases identically the same as those obtained by the committee method, and in no case was there any serious difference; but as the moisture was in all cases nearly or a little over 1 per cent. higher, they would, if calculated to dry substance, be somewhat higher than those obtained by the committee method.

The following interesting results were given also by the same station on different methods of determining the moisture and the fat in the dried residue:

	Corn fodder.	Bran.	Cotton-seed meal.
Moisture by the committee method	6.56	7.84	6.43
Fat in the above	1.45	4.05	13.05
Moisture at 100° in stream of hydrogen	7.33	8.89	7.74
Fat in the above	1.78	4.00	13.42
Moisture at 110-115° in stream of hydrogen	7.73	9.41	7.83
Fat in the above	1.68	4.25	12.50

Name of substance.	Reported by—	Moisture.	In the dry substance.				
			Ash.	Ether extract.	Fiber.	Crude protein.	N-free extract.
Corn fodder.....	Caldwell	5.80	10.59	2.25	29.25	10.90	47.00
	Frear	6.67	10.34	2.15	33.79	10.59	43.13
	Jenkins	6.56	6.60	1.55	20.90	9.90	52.05
	Wilkinson	11.53	8.53	3.31	31.40	9.79	46.97
	Weber	9.04	8.77	2.18	27.88	9.88	51.29
	Peter	7.04	9.48	1.43	24.11	9.56	58.38
Bran.....	Caldwell	8.45	7.52	4.54	10.86	19.57	57.51
	Frear	8.35	7.34	4.51	9.97	17.78	60.40
	Jenkins	7.64	7.01	4.25	8.40	18.13	62.21
	Wilkinson	11.10	6.39	5.79	9.64	16.90	61.28
	Weber	9.90	6.16	4.99	9.10	17.96	61.69
	Peter	8.48	6.19	4.01	7.71	16.75	66.68
Cotton-seed meal....	Caldwell	6.76	9.23	10.68	6.70	50.91	22.46
	Frear	6.98	9.06	12.92	4.25	47.85	24.92
	Jenkins	6.43	8.10	12.88	2.68	49.01	27.18
	Wilkinson	8.37	8.12	14.71	3.56	46.13	27.48
	Weber	7.60	8.01	13.76	3.27	47.55	24.41
	Peter	6.14	7.96	12.28	2.51	46.06	25.05

In the dry substance.

	Corn fodder.		Bran.		Cotton-seed meal.	
	Total.	Albuminoids.	Total.	Albuminoids.	Total.	Albuminoids.
Frear	1.60	1.02	2.85	2.40	7.65	6.20
Jenkins	1.67	1.34	2.91	2.64	7.84	7.64
Peter	1.53	1.21	2.68	2.53	7.87	7.00

Respectfully submitted.

G. C. CALDWELL,
Chairman.
CLIFFORD RICHARDSON,
WM. H. JORDAN,
Committee.

Mr. Richardson said that, in view of the large amount of discrepancy in the results, he believed it advisable to confine future work to one method without alternates. He added that, with the establishment of so many experiment stations during the present year, all of which would be interested in this subject, a very large increase in the number of analysts was to be expected, and the results at the next convention would admit of drawing more definite conclusions. He had found that in the alternate method for determining fiber, recommended last year, the use of bottles could only be made a success when live steam was available. In a water-bath, owing to sudden and unequal heating, cracking seemed unavoidable. Dr. Frear found difficulty in securing concordant results on cotton-seed meal, and regretted the absence of all the analysts but himself, which prevented an interchange of experiences.

On motion of the latter gentleman, the report and recommendations of the committee were adopted.

Dr. Wiley then presented the report of the committee on dairy products, as follows:

REPORT OF THE COMMITTEE ON DAIRY PRODUCTS.

By H. W. WILEY.

Mr. PRESIDENT: I found it impracticable to secure a meeting of the committee appointed at the last meeting to consider the subject of dairy products, and have therefore no report considered by all of the members of the committee to present. In the absence of such a document I thought it best to submit a brief résumé of the work which has been done in dairy products during the year since our convention last met. The methods proposed at our last meeting for the analysis of dairy products have given fairly good satisfaction, and I therefore recommend that they be continued unchanged for another year. Many points which are now in dispute will have been settled by that time, and at our next annual meeting any necessary changes in methods of analysis can be made.

With this introduction I beg to submit the following abstracts of the progress made in the analysis of dairy products during the year just passed.

MILK ANALYSIS.

USE OF ASBESTOS CLOTH INSTEAD OF BLOTTING-PAPER IN THE ADAMS METHOD.

Johnstone has reported to the Society of Public Analysts favorable results attending his experiments in substituting asbestos paper for blotting-paper in the Adams method of fat estimation.—(Abstract from the Analyst, December, 1887, p. 234.)

[NOTE.—I called attention to the use of asbestos paper for this purpose two years ago, as will be seen on page 81 of Bulletin No. 13, Part 1.]

AN INSTRUMENT FOR CALCULATING MILK RESULTS.

Richmond has described an instrument for calculating milk analyses based on the relations existing between fat, solids not fat, and specific gravity in milk as established by the paper of Hehner and Richmond, published in the Analyst, vol. 13, p. 26. The instrument consists of a slide rule on one side of which a scale, of which one division equals 1 inch, represents total solids. The other scale, one division of which equals 1.164 inches, represents the fat; while the scale representing specific gravity has a division equal to 1.254 inches.

The instrument is based upon the formula $T - .254 G = 1.164 F$. To use the instrument the lines indicating total solids and specific gravity found by analysis are placed together. The fat is then read off by an arrow on the other side. Where many analyses are to be made the instrument is especially valuable since it eliminates all chances of error in calculation.—(Abstract from the Analyst, 1888, vol. 13, No. 144, p. 65.)

ESTIMATION OF FAT IN MILK AND CREAM.

Werner Schmid proposes the following method of estimating milk fat: A test tube of about 50 cubic centimeters capacity is graduated in tenths of a cubic centimeter; 10 cubic centimeters of milk or 5 cubic centimeters of cream are placed in the tube and 10 cubic centimeters concentrated hydrochloric acid. The contents of the tube are boiled with constant shaking until the liquid is dark brown. After cooling in water add 30 cubic centimeters ether, shake, allow to stand until the ether solution has separated, measure its volume and remove 10 cubic centimeters with a pipette; place in a porcelain crucible, evaporate, and dry at 100° in air-bath. Calculate to total volume of the ether solution. The results are said to be exact.—(Zeit. Anal. Chem., 27, p. 464.)

THE RELATION OF SPECIFIC GRAVITY, FAT, AND SOLIDS NOT FAT, IN MILK.

Hehner and Richmond have made an exhaustive study of the relations existing between the specific gravity, fat, and solids not fat, in milk. Three sets of determinations of the fat were made, viz, extraction from a paper coil, from plaster of Paris, and the direct extraction of the dried total solids. All previous formulæ relating to the above relations have been based upon imperfect methods of fat extraction. The work of Hehner and Richmond is therefore especially valuable on account of being based upon the Adams method of extraction. Forty-two analyses of various kinds of milk were made. For discussion of the formulæ the original paper is cited. The working formula obtained is $T - .254 G = 1.164 F$.

A table accompanying the paper gives the percentage of fat, calculated for specific gravities ranging from 1024.0 to 1034.0, and for total solids from 10 per cent. to 15 per cent., inclusive.

The author strongly recommends that no milk analyses be accepted as correct which do not correspond closely with the calculated results.—(Abstract from the Analyst, vol. 13, No. 142, p. 26.)

SOURCES OF ERROR IN SOXHLET'S METHOD OF ESTIMATING FAT IN MILK.

Weinwurm has determined the error which may arise by allowing the ether fat solution obtained by Soxhlet's method to stand for varying lengths of time before its specific gravity is determined. As a result of his experiments it appears that the apparent percentage of fat is raised by allowing the solution to stand for a long time. For the first twenty-four hours, however, this increase is only small, the amount, at most, being a few hundredths of a per cent. By standing a long time the apparent percentage of fat gradually increases, and appears to reach a maximum at the end of ten days. The amount of increase in that time may be .25 of 1 per cent.—(Abstract from Repertorium No. 19 of the Chemiker-Zeitung, 1888, p. 151, and M. Zg. 1888, 17, p. 401.)

ESTIMATION OF DRY SUBSTANCE AND FAT IN MILK BY MEANS OF WOOD FIBER.

Gantter proposes the use of wood fiber for the estimation of fat in milk, which he uses as follows:

Two grams of wood fiber are dried at 105° to constant weight in a dish containing a small glass rod. The total weight of the dish, glass rod, and fiber is noted. After weighing the dish, which is covered with a neat-fitting cover to prevent the absorption of water, 5 to 6 grams of the milk are poured upon the wood fiber and the exact amount taken determined by reweighing the bottle. During evaporation the mass of fiber is pressed from time to time against the sides of the dish, so that no particles thereof remain attached thereto. The final drying is made in an air-bath, and the whole time required for the evaporation and drying should be about two hours and a half. From the increase in weight the amount of dry substance is determined. The mass of fiber is now transferred to a Soxhlet extraction apparatus, and, if necessary, the dish rinsed with petroleum ether. The extraction of fat and the weighing thereof are carried on in the usual way. The author has also used this method for the determination of water in butter and other fats and oils.—(Abstract from the Zeitschrift für analytische Chemie, vol. 26, No. 6, p. 678).

THE CHEMICAL ACTION OF SOME MICRO-ORGANISMS IN MILK.

Warington has studied the effect of certain micro-organisms on the curdling of milk. This curdling is effected either by the formation of a rennet-like ferment or by the production of lactic acid. The amount of lactic acid required to curdle milk depends on the temperature, the amount growing less as the temperature rises. Five different organisms were examined which had the power of curdling milk, but in very different

degrees. They were *Staphylococcus candidus*: *B. termo*; *M. gelatinosus*, *B. fluorescent liquefascens*, and *M. ureæ*.

Some of them readily curdled milk at a temperature as low as 10°. They do not, however, at that temperature produce an appreciable acidity. They therefore act plainly as a ferment. A large quantity of gas is evolved during the action of the same on milk.

Five organisms were also found to act as peptonisers; they are, *B. subtilis*, *B. anthracis*, *B. floccus*, *B. toruliformis*, and Finkler's comma. The milk treated with these organisms at 22° becomes clear after a few days. The clear fluid is rich in pepton. A few organisms render milk after a time decidedly alkaline; two of these are, *B. fluorescent non liquescens* and the *Bacillus of septicæmia*.

Cultivation in milk is an excellent method of distinguishing micro-organisms.—(Abstract from the Chemical News, June 22, 1888.)

REDUCTION AND ROTATION POWER OF MILK SUGAR.

Deniges and Bonnans have reviewed the literature concerning the reduction of copper solution by milk sugar. As compared with pure glucose the reducing power of lactose is as 96 to 136. The copper solution employed contained 34.65 grams of pure crystallized copper sulphate and 10 cubic centimeters pure sulphuric acid per liter. The alkaline solution was composed of 250 cubic centimeters of soda lye of 36° strength, in which was dissolved 150 grams of crystallized Rochelle salts. Ten cubic centimeters of this solution was added to each 10 cubic centimeters of the copper solution.

For the determination of the rotatory power of lactose the author used a pure sugar, obtained by three crystallizations. The specific rotatory power for the anhydrous sugar at 20° was 55.30 for concentrations varying from 4 to 36 per cent.; for the crystallized sugar the specific rotatory power in the same condition is 52.53. The general formula for the crystallized salt would be $[a] = 52.53 + (20 - T) \times .055$. The number .055 is the correction to be applied for each variation of 1° in temperature. The numbers obtained by the authors are exactly those given by Schmüger.—(Abstract taken from the Journal de Pharmacie et de Chimie, April and May, 1888, pp. 363 and 411.)

ESTIMATION OF SUGAR IN MILK BY THE POLARISCOPE.

Vieth discusses the method adopted by the Association of Official Agricultural Chemists for the estimation of sugar in milk, which was originally described by me in the American Chemical Journal, vol. 6, No. 5. The author is of the opinion that acetic acid and subacetate of lead can be used with equal advantage with mercuric nitrate and nitric acid for preparing the milk for polarization. He, however, prefers the use of the mercury salt. He calls attention to the correction which should be made in the reading of the polariscope for the volume of the precipitate. According to Vieth this correction in the method adopted by the association is too small. The volume of the precipitate is equal to the combined volumes of the precipitated casein and fat carried down with it. The method employed by Vieth for making the correction for the volume of the precipitate is illustrated by the following example:

Given a milk with a specific gravity of 1.0325 which contains 3.72 of fat. Add to 50 cubic centimeters of this milk 14 cubic centimeters of the mercuric nitrate solution. The polarization of the filtrate shows 5.1 milk sugar. The necessary calculations for the correction of this number are as follows:

$$93 : 100 :: 372 : X \text{ whence } X = 4$$

the volume occupied by the fat.

$$103.25 : 96 :: 51 : X \text{ whence } X = 4.74.$$

The number 96 in the above formula represents 100 cubic centimeters of the liquid less 4 cubic centimeters, the volume of the fat. The number 4.74 represents the per-

centage of crystallized milk sugar. The percentage of the anhydrous milk sugar would therefore be 4.5.—(Abstract from the Analyst, vol. 13, No. 144, p. 63.)

SHORT'S METHOD OF DETERMINING FAT IN MILK.

[Bul. Wis. Ag. Ex. Station, No. 16.]

The process depends on the following facts: That when a mixture of milk and a strong alkali is heated to the temperature of boiling water for a sufficient time the fat of the milk unites with the alkali and forms a soap which is dissolved in the hot liquid; at the same time the casein and albumen are disintegrated and become much more easily soluble. After the heating has continued for about two hours the mixture of milk and alkali becomes homogeneous and of a dark brown color. On the addition of an acid the soap is decomposed, the fatty acids are set free, and rise to the surface, while the albumen, casein, etc., are first precipitated and then dissolved. The insoluble fatty acids thus obtained constitute very nearly 87 per cent. of the total fat of the milk.

APPARATUS.

The process requires the following apparatus:

(1) Tubes made of soft lead glass about one-sixteenth inch thick. The lower part of the tube is about 5 inches long and fifteen-sixteenths of an inch in diameter. The upper part of the tube 5 inches long and one-fourth inch inside diameter.

(2) Three pipettes, one holding when filled up to the mark on the neck 20 cubic centimeters (about two-thirds of an ounce), this being the exact amount of milk to be taken for analysis; the other two pipettes, holding 10 cubic centimeters each, for measuring the alkali and acid used.

(3) A scale, divided in millimeters, for measuring the column of fat when the analysis is finished. The one used by the writer is a folding boxwood rule, but any rule divided in millimeters will answer the purpose.

(4) A water bath made of sheet copper. It is provided with a rack to hold the tubes while being heated; also a feed and overflow to keep the water in the bath at a constant level.

(5) A wash bottle to hold hot water.

SOLUTIONS REQUIRED.

The solutions required for the process are as follows:

No. 1.—8.75 ounces (250 grams) caustic soda and 10.7 ounces (300 grams) caustic potash dissolved in 4 pounds (1,809 grams) water. Use 10 cubic centimeters for each analysis.

No. 2.—Equal parts of commercial sulphuric and acetic acids. The acetic acid should be of 1.047 specific gravity. Use 10 cubic centimeters of the mixed acids for each analysis.

DIRECTIONS FOR ANALYSIS.

Taking samples.—Mix the milk thoroughly by pouring from one vessel to another, avoiding as much as possible the formation of air bubbles; warming the milk to 80 or 90 degrees Fahrenheit will prevent frothing to a large extent. After mixing, allow the milk to stand one or two minutes, to permit the air bubbles to escape before taking samples. Fill the 20 cubic centimeter pipette by placing the lower end in the milk and sucking until the milk rises in the tube above the mark on the side. Place the finger quickly on the top of the tube and allow the milk to run out slowly until it falls to the mark on the side of the tube; then let the contents of the pipette run into one of the analytical tubes, blowing out the last few drops.

Adding the alkali.—Fill one of the 10 cubic centimeter pipettes to the mark on the side with alkali, and allow the solution to flow into the milk just measured. Place

the finger on the top of the tube and shake the tube until the milk and alkali are well mixed. A rubber cot on the finger will protect it from the action of the alkali. Treat all samples in the same way. Place the tubes in the rack, set the rack and tubes in the water bath, and heat the bath until the water boils; continue boiling for two hours, or until the contents of the tube become homogeneous and of a dark brown color similar to that of sorghum molasses. After the tubes have boiled for one hour remove the rack and tubes from the bath and examine the tubes to see if the contents are well mixed. If a whitish layer of casein and fat is found floating on the surface of the liquid gently shake and roll the tubes until the contents are well mixed. Return tubes to water bath and boil one hour. The tubes are then ready for the addition of the acid.

Adding the acid.—Remove the rack with the tubes from the water and allow them to cool to about 150 degrees Fahrenheit. Then, by means of the pipette, add 10 cubic centimeters of the acid mixture to each tube, slowly, so as not to cause the contents of the tube to froth over. Mix the acid with the contents by running a small glass tube to the bottom of the mixture and blowing gently. Place the rack and tubes again in the bath and heat to boiling for one hour. Remove the tubes from the water, and then, by means of the water-bottle, fill the tubes with hot water to within 1 inch of the top. The fat will then rise to the top of the water. Replace the tubes in the bath and allow them to stand in the hot water, without boiling, for one hour. At the end of this time remove the tubes from the bath, one at a time, and measure while hot.

Measuring the fat.—The analyst will observe that the lines representing the upper and lower limits of the column of fat do not extend straight across the tubes, but are slightly curved. In measuring the column of fat place the rule on the tube so that the lower line will come opposite the lowest part of the curved line of the fat; then read up the scale to the division coming opposite the lowest part of the upper curved line. The number of divisions on the rule is the length of the column of fat in millimeters. The per cent. of fat in the milk is then calculated from the following formula and data:

Amount of milk taken, 20 cubic centimeters.

Specific gravity of milk, 1.032.

Specific gravity of insoluble fatty acids, .914

Per cent. of insoluble fatty acids in butter fat, 87.

From the above data we have the following formula:

$$100 \frac{a \times b \times c}{d \times e} = x$$

Where a = the length of the column of fat in millimeters.

b = the value of one linear millimeter of measured fat expressed in cubic centimeters. The value of b will vary according to the size of the tube used.

c = specific gravity of the insoluble fatty acids.

d = 20.64 grams or the volume of milk taken for analysis multiplied by its specific gravity.

e = per cent. of fat present in sample of milk taken for analysis.

Substituting the figures obtained by an actual analysis the formula would be—

$$100 \frac{30 \times .027 \times .914}{20.64 \times .87} = x = 4.12$$

per cent. of fat in sample of milk analyzed.

(NOTE.—The neck of the tubes can be graduated in cubic centimeters, removing the necessity of the troublesome measurements mentioned above.—H. W. W.)

If the process has been conducted according to the above directions the column of fat will be free from impurities and the line of separation between the water and fat

will be perfectly clear. On first rising to the surface the fat is slightly turbid owing to the presence of a small quantity of water. Although this will make no appreciable difference in the measurement of the fat it may, if desired, be obtained perfectly clear by removing the tubes from the bath and allowing them to cool slowly. The crystallization of the fat causes the finely divided water, which is distributed through the fat, to collect in drops, which sink to the bottom when the tubes are again heated, leaving the fat perfectly clear.

The analyst may fail to obtain correct results from the following causes: Either the column of fat may contain flecks of undecomposed casein, which would increase the volume of fat, thereby giving too high a per cent., or a small quantity of butter fat may remain unsaponified, which will also give too high results. These errors are both caused by insufficient heating of the milk with the alkali, and may be easily obviated by taking care to heat the mixture of milk and alkali for two hours at least. If not pressed for time it is better to heat two and one-half hours, and thereby remove all risks of the above errors. If milk containing more than 6 per cent. is to be tested the mixture of milk and alkali should be heated at least three hours. In such case it would be better, perhaps, to take 10 cubic centimeters in place of the usual amount.

Before adding acid the tubes and contents must be allowed to cool to 150° Fahrenheit at least. If added at a higher temperature the contact of the strong acid with the hot alkali solution will generate sufficient heat to cause the contents of the tube to boil with explosive violence, throwing out the contents of the tube and spoiling the analysis. If after the addition of hot water the tubes are allowed to stand in boiling water, small bubbles of gas are given off by the continued action of the acid on the casein. These bubbles rise through the column of fat, rendering it turbid, and causing difficulty in measuring. The bottles containing the solutions of acid and alkali should be kept corked when not in use. If the acid bottle be left open the acetic acid will evaporate and the acid will not dissolve the casein. The alkali bottle should be kept closed to prevent absorption of carbonic acid and consequent weakening of the solution.

(NOTE.—The method of Short has been compared in my laboratory with the anhydrous copper method of Piggott & Morse. A mean of 12 determinations gave by the anhydrous copper method 3.20 per cent. of fat, and by the Short method 3.18 fat. The same samples treated by the Adams method gave results considerably higher. The process of Short has also been improved by graduating the neck of the tube into tenths of a cubic centimeter.

For use at stations where expensive chemical apparatus can not be had, the method appears to have great value.—H. W. W.)

BICARBONATE OF SODIUM IN MILK.

Proust makes an energetic protest against the addition of bicarbonate of sodium to milk for the purpose of preserving it. His principal objection to the use of the above salt is based upon its action on lactic acid, the lactate of soda being a salt injurious to children.—(Abstract from *Chemisches Central-Blatt*, No. 24, 1888, p. 837.)

BUTTER ANALYSIS.

ACTION OF ALCOHOL ON BUTTER FAT.

Cochran has made experiments on the solubilities of the different glycerides of butter in alcohol with reference to the quantity of volatile acid which the dissolved and undissolved portions would yield when treated by Reichert's method. As a result of the work it is seen that that portion of the glycerides dissolved by ethyl or methyl alcohol is richer in volatile acids than the undissolved portions. The iodine number of the dissolved fat is less than the undissolved fat. The melting point of the fats dissolved by alcohol is less than that of the undissolved fats,

The above facts would be of importance in the examination of butters to which it is suspected artificial butyrates may have been added.—(Abstract from the Analyst, vol. 13, p. 55.)

A QUICK METHOD OF DISTINGUISHING OLEOMARGARINE IN BUTTER.

Dubernard has proposed the following method for a qualitative examination of butter for oleomargarine. The method rests upon the observation that pure butter vigorously shaken with ammonia at a temperature of from 70° to 80° and afterwards heated to 100° produces only a small amount of foam, which does not last a long time. Margarine, on the contrary, produces a large quantity of lasting foam. In order to distinguish butter from margarine by this method, the following manipulation is pursued.

In a test tube place about 3 grams of the butter to be examined. Heat to 95° or 100° in a water bath, and then allow to cool to about 80°. Add to the melted substance 5 cubic centimeters of ammonia, shake vigorously, and place again in the water bath and heat to 95° or 100°. The ammonia is volatilized with the formation of foam. The foam in the tube rises more or less according as the butter contains a larger or smaller quantity of oleomargarine. In mixtures of pure butter with known quantities of margarine the tube can be graduated and the relative quantities of butter and margarine thus approximately determined.—(Abstract from *Chemiker-Zeitung*, 1888, No. 46, p. 760.)

DETECTION OF ADULTERATIONS IN BUTTER.

Bockairy proposes the following method for the detection of adulterations in butter which rest upon the different solubilities of fats in toluene:

Place in a test tube 15 cubic centimeters of pure toluene, add 15 cubic centimeters of the filtered fat and 40 cubic centimeters of strong alcohol at 18°; the toluene holding in solution the fatty matter remains at the bottom of the tube. By means of a water bath the tube is heated to 50° and thoroughly shaken. If the sample is of butter fat or a mixture of butter fat and some other kind, there is no turbidity; but if no butter be present a turbidity is at once manifested. The tube is placed in water at a temperature of 40° for half an hour; pure butter gives no turbidity at the end of that time, but if other fats are present the mixture will appear turbid.—(Abstract taken from the *Chemical News*, July 6, 1888, p. 11, and *Bul. de la Societe Chimique de Paris*, vol. 49, No. 5, p. 331.)

DIFFERENCE BETWEEN NATURAL AND ARTIFICIAL BUTTER.

C. J. van Lookeren proposes the following for a characteristic test between pure and falsified butter:

A small amount of butter is melted in a teaspoon, and a drop thereof placed in boiling water contained in a watch glass. If the butter be pure a thin film of fat is formed upon the hot water, which breaks up into numerous fat globules, which tend to collect quickly at the periphery. With oleomargarine, etc., a thin film of fat is formed in the same way, which, however, breaks up into only a few large drops, which remain distributed over the whole surface of the water. The conditions for the success of the experiment are that the water be perfectly pure and clear, and the melted butter fat very hot.—(Abstract in the *Repertorium of the Chemiker-Zeitung*, No. 18, 1888, p. 143, from the *Milchztg*, 1888, No. 17, p. 362.)

A MODIFICATION OF KOETTSTOEFER'S AND REICHERT'S PROCESSES.

Lowe has proposed the following method of determining the volatility and saponification equivalent of butter and other fats:

About 2 grams of the filtered fat are saponified with 10 cubic centimeters of normal alcoholic potash in a stoppered flask. The alcohol is then boiled off and the soap

dissolved in 50 cubic centimeters of hot water. The excess of potash is then determined with semi-normal sulphuric acid solution. The saponification numbers having thus been determined enough additional sulphuric acid is run in to make 25 cubic centimeters in all. The flask is then connected to a condenser and 50 cubic centimeters distilled off, filtered, and determined in the usual way. The same flask is used throughout the whole process, one of 200 cubic centimeters capacity answering the purpose very well. The whole process does not occupy more than two hours, and can be completed often in less time.

Tyrer, criticising the process of Mr. Lowe, was of the opinion that the quantity of fat taken, 2 grams, was too small, since it gave only about one-tenth of a gram of volatile fatty acids. The alkali also dissolved some of the glass, thus introducing an error of which no account was taken. Carbonic acid, moreover, expelled by this method, increased the apparent estimate of filtered fatty acids.—(Abstract from the Journal of the Society of Chemical Industry, March, 1888, p. 185; May, 1888, p. 376.)

SAPONIFICATION WITHOUT THE USE OF ALCOHOL.

Mansfeld, in order to avoid the losses due to etherification during saponification in the presence of alcohol, has proposed to carry on the process of saponification, preparatory to the estimation of volatile acids in butter, without the use of alcohol. The method employed is as follows:

Five grams of the melted and filtered butter fat are taken; into the melted fat are allowed to run 2 cubic centimeters of a potash lye containing 100 grams caustic potash in 100 cubic centimeters of water. The flask is closed with a stopper carrying a glass tube drawn out to a capillary point; the flask is then placed in an air bath heated to about 100° and allowed to remain for two hours. At the end of that time the saponification is completed. One hundred cubic centimeters of water are now added, the flask placed in a water bath until the soap is dissolved, which is decomposed and subjected to distillation in the usual way.—(Abstract in *Chemisches Central-Blatt*, June 23, 1888, p. 870, from *M. Z.*, No. 17, pp. 281-53).

WOLLNY'S CRITICISM OF THE REICHERT-MEISSEL METHOD.

The method of determining volatile fatty acids devised by Reichert has, during the past year, been subjected to an extended criticism by Dr. R. Wollny, of Kiel. Dr. Wollny, as a result of 98 analytical tests, was convinced of the truth of the statement of Professor Fresenius, that the Reichert method was totally unreliable for the determination of very small quantities of butter in oleomargarine.

As a result of his analytical work Dr. Wollny was convinced that the chief source of error in the Reichert work was due to the absorption of carbonic acid. He asserts that the error which may arise from this source must amount to as much as 10 per cent. butter, and renders the results obtained by the method quite inaccurate. It being very difficult to secure an alkali free from carbonate, the author decided to use a 50 per cent. solution of caustic soda instead of potash, since in a solution of that strength the chloride, nitrate, sulphate, and carbonate of soda are quite insoluble.

An arrangement was also devised by which the solution of caustic soda could be kept and drawn off for use without risk of absorption of carbonic acid. Such a solution made and kept in this way gave for 3 cubic centimeters treated by the ordinary process of Reichert's distillation an amount of volatile acid sufficient to neutralize from .2 to .3 cubic centimeters of the deci-normal barium hydrate solution. The author's precautions to prevent absorption of CO₂ are wholly unnecessary when the saponification is carried on in closed flasks.

Dr. Wollny further discusses the errors due to the formation of butyric ethers during saponification and distillation, and also the error due to the mechanical translation of particles of insoluble fatty acids during the process of distillation, and the

error due to the shape and size of the vessel in which the distillation is carried on and the time of its duration. The magnitude of these errors he states as follows:

(1) Due to absorption of carbonic acid +10 per cent. (2 and 3) Formation of butyric ether —13 per cent. (4) Cohesion of fatty acids —30 per cent. (5) Shape and size of vessel + or —5 per cent.—(M. Z., 1887, Nos. 32, 33, 34, 35. and the Analyst, 1887, Nos. 139, 140, 141, 142.)

Dr. Wollny further describes the exact methods to be employed in the examination and the results obtained, for the details of which I refer to the original papers.

As president of the butter commission of the German Dairy Association, Dr. Wollny has proposed the following method to be employed in the comparative examinations of butter for the forthcoming report of the commission (see M. Z. No. 25, 1888). In the preparation of the deci-normal barium solution each one of those taking part in the analyses has been furnished with samples of normal sulphuric acid, pure crystallized chloride of barium, and pure peroxalate of potash. In addition to this for testing the refractometer samples of olive oil, nitrobenzol and monobromnaphthalin have been sent. Following are the details given by Dr. Wollny for the preparation of the reagents and the conduct of the analysis.

METHOD PROPOSED BY DR. WOLLNY FOR THE EXAMINATION OF BUTTER FOR THE COMMISSION OF THE GERMAN DAIRY UNION.

[From the Milch Zeitung, 1888, No. 25 et seq.]

(1) PROVING THE WEIGHTS AND BURETTES.

The weights which are to be used must be carefully compared and the burettes calibrated.

(2) ESTIMATION OF THE STRENGTH OF NORMAL SULPHURIC ACID.

A clean dry dropping bottle of about 60 grams content, the tip of which is touched with vaseline on the outside, is carefully weighed; 35 or 40 grams of normal sulphuric acid are then placed in it and it is again weighed. Afterwards five portions in duplicate of about 3 grams are weighed in a beaker glass of 300 cubic centimeters capacity. The drop bottle being weighed after each portion, the exact weight of the normal sulphuric acid is determined. One hundred cubic centimeters of recently boiled distilled water are added to each of the portions. One hundred cubic centimeters of this distilled water must not require more than 2 drops of barium solution to give color after 1 cubic centimeter of the phenolphthalein solution has been added. The samples are heated in the water bath to the boiling point and to each portion as many cubic centimeters of dilute barium chloride solution added that for each gram of the normal sulphuric acid there are present 10 cubic centimeters of the BaCl_2 . The barium chloride solution contains 15 grams of the salt in 1 liter of distilled water. Afterwards the beakers are covered with watch glasses and allowed to stand for fifteen minutes over the water bath. The precipitates are to be collected upon ash free filters of 9 centimeters diameter and washed with hot distilled water until the chlorine action disappears. After drying and incineration the weight obtained is to be multiplied by the factor .34331. The five duplicate portions, after the addition of 1 cubic centimeter of phenolphthalein solution, are treated with barium solution until the red color appears. The numbers obtained are to be calculated to 100 grams of the normal sulphuric acid.

(3) ESTIMATION OF SATURATION OF THE NORMAL SULPHURIC ACID BY THE BARIUM SOLUTION.

From the results obtained by the above analyses the exact strength of the deci-normal barium solution is to be determined.

(4) TITRATION OF BARIUM SOLUTION WITH POTASSIUM PEROXALATE.

One gram of the peroxalate of potassium, after drying for twelve hours in a desiccator over sulphuric acid, is placed in a weighing bottle similar to the one described above,

Sixty grams of hot distilled water are then added, and after the salt has been dissolved and the solution cooled the weighing bottle is again weighed. About 12 grams of the solution are now run into each of five beaker glasses, and the exact amount in each one determined by reweighing the weighing bottle. Ninety cubic centimeters of recently boiled distilled water are now added, together with 1 cubic centimeter of phenol phtalein solution. The barium solution is now added until the red color, which at first disappears, remains for at least five minutes. The results are calculated to the strength of the barium solution according to the formula—

$$T = \frac{10000 \times p (b-t)}{84.5 n (l-t)}$$

in which

t = the weight of the weighing bottle empty.

b = the weight of the weighing bottle + the peroxalate.

l = the weight of the weighing bottle + the peroxalate solution.

p = the weight of the portion of the solution employed.

n = the number of cubic centimeters of barium solution used.

(5) ESTIMATION OF THE VOLATILE ACIDS AFTER SAPONIFICATION WITH THE AID OF ALCOHOL.

Five grams of the butter fat are weighed into an Erlenmeyer flask; 10 cubic centimeters of alcohol at 96 per cent. and 2 cubic centimeters of concentrated soda lye at 50 per cent., which has been preserved in an atmosphere free of carbonic acid, are added. The flask, furnished with a reflux condenser, is heated, with occasional shaking, in a boiling water bath for one-quarter of an hour. The alcohol is then distilled off by allowing the flask to remain for three-quarters of an hour in a boiling water bath. One hundred cubic centimeters of recently boiled distilled water are then added and allowed to remain in the water bath until the soap is dissolved. The soap solution is then immediately decomposed with 40 cubic centimeters of dilute sulphuric acid (25 cubic centimeters sulphuric acid to 1 liter), and the flask immediately connected with the condenser. This connection is made by means of a 7 millimeters diameter glass tube which, 1 centimeter above the cork, is blown into a bulb 2 centimeters in diameter; the glass tube is now carried obliquely upwards about 6 centimeters and then bent obliquely downward; it is connected with the condenser by a not too short rubber tube. The flask is now warmed by a small flame until the insoluble acids are melted to a clear transparent liquid. The flame is now turned on with such strength that within half an hour exactly 110 cubic centimeters are distilled off. One hundred cubic centimeters of the distillate are now filtered off, placed in a beaker glass, 1 cubic centimeter of phenolphthalein solution added and titrated with barium solution; when the red color is shown the contents of the beaker glass are poured back into the measuring glass in which the 100 cubic centimeters was measured, again poured back into the beaker, and again titrated with the barium solution until the red color becomes permanent. The distillation should take place in as nearly thirty minutes as possible.

(6) ESTIMATION OF THE VOLATILE ACIDS AFTER SAPONIFICATION WITHOUT ALCOHOL.

Five grams of the butter fat are saponified with 2 cubic centimeters of concentrated potash lye preserved from contact with carbonic acid. The lye solution is made by dissolving 100 grams of the potash in 58 grams of water. By gentle rotation of the flask the lye and fat are intimately mixed together; the flask is then placed in a vertical position over a boiling water bath until the mixture becomes solid. It is then placed obliquely in the water bath. After it has remained here for two hours it is taken out and the remainder of the process continued as above.

(7) ESTIMATION OF THE MEAN MOLECULAR WEIGHT OF THE VOLATILE FAT ACIDS.

The soap solution obtained by the titration of barium hydrate in number 6 is placed in a weighed platinum dish evaporated to dryness in the water bath, dried in a drying oven for two hours and again weighed.

(8) ESTIMATION OF VOLATILE FAT ACIDS BY DISTILLATION FROM MAGNESIUM SALTS.

Eight grams of butter fat are placed in an Erlenmeyer flask, treated with 3 cubic centimeters of concentrated potash lye and 15 cubic centimeters of alcohol as in number 5, and the alcohol then distilled off. The soap, dissolved in 100 cubic centimeters of water, is washed with 250 cubic centimeters of water in a measuring flask of 500 cubic centimeters capacity and cooled to the temperature of the room. Then by means of a pipette, with constant shaking, 50 cubic centimeters of magnesium sulphate solution, 15 per cent. strength, are added, the flask filled up to the mark with water and vigorously shaken. The mixture is now placed upon an 18 centimeter filter and 300 cubic centimeters filtered into a measuring flask. The filtrate is brought into a flask holding about 500 cubic centimeters, which on the one side is joined with a steam generator and on the other with a condenser. Two cubic centimeters of strong sulphuric acid together with two pieces of pumice stone are added. Two hundred and fifty to 275 cubic centimeters are now distilled off into a measuring flask of 500 cubic centimeters capacity, the distillate being filtered into the flask through a moistened filter. The gas flame under the distillation flask is then turned down low and the distillation continued in a current of steam until the 500 cubic centimeters flask is full. After the filter which has been used has been washed with a little water the distillate is placed in a large flask of 1 liter capacity and 2 cubic centimeters of phenolphthalein added and titrated.

(9) ESTIMATION OF THE VOLATILE FATTY ACIDS FROM COPPER SALTS.

The estimation is carried on exactly as in No. 8 substituting 50 cubic centimeters of copper sulphate solution for the 50 cubic centimeters of magnesium salts. In the present case the distillate may be collected directly in the one-half-liter flask without filtration, since by precipitation with copper sulphate solution no insoluble fatty acids pass over during distillation.

(10) ESTIMATION OF VOLATILE FATTY ACIDS BY DISTILLATION IN A CURRENT OF STEAM, ACCORDING TO GOLDMANN.

Five grams of butter fat are weighed in a long-necked flask of about 300 cubic centimeters capacity. Ten cubic centimeters alcohol and 2 cubic centimeters potash lye are added and the flask connected, on the one hand, with a steam generator, and on the other with a condenser. The contents of the flask are now warmed with a small flame for twenty minutes the condenser being directed obliquely downward and, in a measuring cylinder, 6 cubic centimeters distilled off. The steam is then directed into the flask and 50 cubic centimeters more collected. The soap is now decomposed with 5 cubic centimeters of sulphuric acid (20 cubic centimeters strong acid diluted to 100 cubic centimeters) the separated fat acids heated with a small flame until they form a clear solution and in a current of steam the volatile acids distilled off into a 500 cubic centimeter flask. The size of the flame is so regulated that the contents of the distillation flask remain constant at about 30 to 40 cubic centimeters, and the distillation is continued until each succeeding 500 cubic centimeters, after the addition of 2 cubic centimeters phenolphthalein solution, require not more than 2 cubic centimeters of the deci-normal barium solution to produce the red color.

(12) ESTIMATION OF THE FATTY ACIDS SOLUBLE IN 10 PER CENT. ALCOHOL.

(a) *Roses method.*—12.5 grams of butter fat are weighed into a graduated flask of 500 cubic centimeters capacity, 50 cubic centimeters of alcoholic potash lye (about 112

grams of potassium hydrate dissolved in absolute alcohol and made up to 1 liter), are added and gently shaken. After five minutes as slight an excess of semi-normal sulphuric acid as possible is added. After two minutes dilute with water to 490 cubic centimeters; to destroy the foam, add 5 cubic centimeters more absolute alcohol, fill up to the mark with water and then add as much more water as will correspond to the amount of fat taken. The flask is now shaken, contents filtered through a dry filter and 250 cubic centimeters of the filtrate titrated with deci-normal potash lye.

(b) *Modification of the above process by Dr. Wollny.*—Weigh 6.25 grams of the fat in an Erlenmeyer flask of 300 cubic centimeters capacity. Add 25 cubic centimeters of potash lye, made with absolute alcohol as described above, and then diluted with absolute alcohol until not more than 74 cubic centimeters and not less than 73 cubic centimeters of semi-normal sulphuric acid are required to neutralize it. The flask is then closed with a stopper which carries a glass tube 10 millimeters wide and 50 centimeters long; heat with a very small flame until the contents are near the boiling point for about twenty minutes and until the smell of the butter ether has entirely disappeared. The flask is then cooled in water and 150 cubic centimeters of recently-boiled distilled water added. When the soap is dissolved and the whole mass cooled to about 15° , 75 cubic centimeters semi-normal sulphuric acid are added. The flask is then closed with a rubber stopper and shaken vigorously for one minute. Filter through a strong dry-folded filter into a graduated flask holding 200 cubic centimeters, pour the 200 cubic centimeters into a large beaker glass, and titrate with barium solution.

(13) ESTIMATION OF INSOLUBLE FAT ACIDS.

Treat 3 to 4 grams of the butter fat with 2 cubic centimeters concentrated soda lye and 10 cubic centimeters alcohol in a porcelain dish on the water bath and evaporate the soap to dryness. Dissolve the soap with 100 cubic centimeters of hot water, add 5 cubic centimeters concentrated sulphuric acid, and heat the separated fatty acids for one hour on the water bath. Pour the contents of the dish on a filter of 11 centimeters diameter, made of the best thick Swedish filter paper previously dried and weighed. Upon this filter the acids are washed with 1.5 liters of boiling water. The filter with the insoluble fatty acids, after they have solidified, is placed in a weighed beaker glass, dried for two hours in an air bath, and weighed.

(16) ESTIMATION OF THE FREE FAT ACIDS.

Ten grams of the butter fat are placed in a beaker glass with 20 cubic centimeters of ether and 10 cubic centimeters of alcohol and 1 cubic centimeter phenolphthalein solution. The free acids are then titrated with deci-normal alcoholic potash.

(11, 14, 15, 17, 18, 19) COMBINED ESTIMATION OF THE SAPONIFICATION NUMBER, THE VOLATILE, SOLUBLE, AND INSOLUBLE FAT ACIDS.

(a) *Saponification number.*—Five grams of the fat are weighed into an Erlenmeyer flask and 25 cubic centimeters of alcoholic potash added. (Twenty-five cubic centimeters alcoholic potash should saturate from 45 to 50 cubic centimeters semi-normal sulphuric acid.) The mixture should be warmed as in No. 5 for a full hour with the reflux condenser. Meanwhile the same quantity of alcoholic potash should be exactly titrated with the semi-normal sulphuric acid, and later being titrated by the barium solution used and the number obtained noted. The alcoholic soap solution is taken from the waterbath, the solid parts adhering to the walls of the flask dissolved by gentle shaking, and, after the addition of 1 cubic centimeter phenolphthalein solution, titrated with semi-normal sulphuric acid. The number obtained is subtracted from the number obtained in the blank experiment and calculated back to the corresponding number of cubic centimeter's barium solution.

(b) *Volatile fat acids.*—The alcohol is driven off from the exactly neutralized alcoholic soap solution obtained in the foregoing experiment, and then an additional

amount of sulphuric acid added, amounting to 2 cubic centimeters more than necessary to neutralize the original potash lye employed. The mixture is then diluted with 140 cubic centimeters of recently-boiled distilled water and two pieces of pumice stone added, and, as in No. 5, 110 cubic centimeters distilled off, of which 100 cubic centimeters, after filtration, is titrated.

(c) *Soluble fat acids*.—After the end of the foregoing experiment the distillation flask is removed from the distillation tube and replaced by one filled with distilled water and placed as a receptacle under the condenser. The condensation water is now allowed to flow from the condenser and the condensed insoluble fatty acids driven over into the original distillation flask by a current of steam. In like manner the insoluble acids collected upon the filter are washed into the original distillation flask. After the fatty acids are solidified the whole of them are brought into a cylinder 3.5 centimeters wide and 15 centimeters long, which ends in a 6-millimeter wide tube carrying a goose-necked glass tube from its side; and on the lower end is closed with a rubber tube and pinch cock. The lower contraction of the cylinder is stopped with a plug of glass wool which forms a thick filter but allows hot water to run through easily. Under the goose neck of this wash vessel, which is held in a vertical position by a retort holder, is placed a graduated flask of 500 cubic centimeters capacity into which the excess of water flows. When the acids have been brought from, the distillation flask, together with the pieces of pumice stone into the wash flask, any residue is washed out with the washing bottle with boiling water. The above must be so conducted that no drops of the fatty acid pass through the glass wool and that no fatty acid remains on the upper walls of the washing flask. The washing flask is furnished with a gum stopper carrying two holes. Through the one passes a tube for the inlet of steam; through the other a tube at least 8 millimeters in diameter, cut off obliquely at the lower end and divided above the stopper into two branches. By means of one of these branches it is connected with a perpendicular condenser, at least 8 millimeters wide, and through the other it is connected by means of a rubber tube and pinch cock with a hot-water reservoir by means of a U-tube reaching to the bottom thereof. Through the steam tube, which is somewhat bent at the end, so that the steam is directed obliquely downwards and outwards against the sides of the washing bottle, a current of steam is conducted which stirs up in a lively manner the surface of the fatty acids, which swim upon the top of the water, while the condensed water drops back out of the reflux condenser in a boiling-hot condition and the excess flows through the goose neck into the measuring flask. The wash water collected in the 500 cubic centimeter flask is titrated with barium solution, with the addition of 2 cubic centimeters phenolphthalein solution. This operation is repeated three times; in all, 1.5 liters of wash water being collected. The total amount of barium solution required in the three operations is collected in one number.

(d) *Insoluble fatty acids*.—After the end of the foregoing experiment the wash flask is cooled until the fatty acids are solidified. The pinch cock closing the lower opening of the wash flask is opened, the water allowed to flow off, and a current of air passed through the apparatus by means of an aspirator after the opening of the goose neck is lightly stoppered and the steam generator removed. The wash flask together with the fatty acids and the glass wool plug are completely dried in this manner after, at most, half an hour. The steam generator is now replaced with a flask which contains ether free of water, alcohol, and acids. The ether is brought to the boiling point by means of warm water and its vapor condensing in the washing flask dissolves the fatty acids and carries them into the weighed flask of about 100 cubic centimeters capacity placed below to receive them. When about 40 or 50 cubic centimeters of ether have distilled over, the operation is broken, the outer end of the wash flask washed with ether and the weighed flask below is placed in a warm place in order to drive off the ether. The weighed flask containing the acids is now warmed in the water bath and placed under the receiver of an air pump. After the acids are completely

freed from ether by this method the flask is again weighed and the weight of the acids noted.

(e) *Mean molecular weight of the insoluble fat acids.*—The fatty acids obtained in the foregoing experiment are melted at a low temperature and from .8 to 1 gram weighed in a beaker glass, dissolved in 50 cubic centimeters of alcohol, 1 cubic centimeter phenolphthalein solution added and titrated with barium solution.

(20) DETERMINATION OF THE IODINE NUMBER.

Weigh out from .8 to 1 gram butter fat in a flask of about 200 cubic centimeters capacity furnished with a glass stopper; dissolve in 10 cubic centimeters chloroform, and add 20 cubic centimeters iodine solution. In case the liquid is not clear, more chloroform must be added. If the iodine color should rapidly disappear add from 5 to 10 cubic centimeters more. The amount of iodine added should be sufficient to secure strong colorization after standing two hours. Add 10 to 15 cubic centimeters iodide of potassium mixture and 150 cubic centimeters of water; titrate with thiosulphate of sodium solution until the iodine has almost disappeared. Add then a little starch solution, and continue titration until the blue color has disappeared.

(21) ESTIMATION OF REFRACTIVE INDEX.

Set the large Abbe refractometer with water at 18° so that the index reads 1.3330. The instrument should then be placed in a room which is kept at a temperature of about 25°. The estimation of the refractive index of butter fats can not be made below 25° on account of the solidification of the fat. The instrument is also to be tested at 20° with olive oil, nitrobenzol and monobromnaphthalin.

(25) DETERMINATION OF THE SPECIFIC GRAVITY AT ZERO OR 15°.

A platinum crucible is supplied with a platinum wire handle so that it can be suspended from the hook of the balance. It is then weighed empty and afterwards its specific gravity taken in water at zero. The water is kept at zero by being placed in a small beaker glass, which in turn is put in a larger beaker closed and surrounded with finely pounded ice. The crucible is then dried and 15 grams of melted butter fat placed therein. The butter fat is allowed to solidify slowly at a temperature not below 15°. The crucible with its contents is then weighed in the air and placed in distilled ice-cold water for an hour. The whole is then weighed in water at zero as before. From these results the specific gravity of the fat at zero is determined. In the same way determine the specific gravity at 15°.

(26) ESTIMATION OF THE SPECIFIC GRAVITY IN BOILING WATER BY MEANS OF THE PYKNOMETER.

A small flask of 50 grams, the neck of which is drawn out to a narrow tube and marked at the narrow place, is weighed empty. It is then filled with distilled water to the mark and placed for an hour in finely pounded ice. The contraction of the water is restored by the addition of ice-cold water until the mark is reached; it is then dried, allowed to come to the temperature of the room, and weighed. The same flask is then filled to the mark with boiling water, and, after coming to the temperature of the room, weighed. The flask is then emptied, dried, filled with melted butter fat, kept in a boiling-water bath for an hour, the butter fat filling to the mark, afterwards cooled to the temperature of the room, and weighed.

(27) ESTIMATION OF THE SPECIFIC GRAVITY WITH MOHR'S BALANCE.

This is determined in the usual manner by the use of a specific gravity bob, the thermometer of which is arranged so as to show a temperature of 100°.

(28) ESTIMATION OF THE SPECIFIC GRAVITY WITH THE AREOMETER IN BOILING WATER.

This is determined by means of spindles furnished by the firm of G. C. Gerhard, in Bonn. These spindles are graduated especially for specific gravity at a temperature of 100°.

(29) ESTIMATION OF THE MELTING POINT.

This is determined in straight or U-formed capillary tubes. They are filled with butter fat at 100° and placed in ice-water for a quarter of an hour. The capillary tube is then placed, with a thermometer, in a beaker glass with water at 20° and slowly warmed with a small flame.

(30) ESTIMATION OF THE SOLIDIFYING POINT.

Place about 100 cubic centimeters of the melted fat in a test tube at 40°. Stir with a thermometer until the fat begins to solidify, the test tube meanwhile being placed in a large vessel containing water at 20°. The temperature will rise slightly when the solidification begins, and the highest point reached is entered as the solidification point.

NOTE.—Dr. Wollny has proposed in the above scheme an exhaustive study of butter fat. Many points appear to be superfluous and others elaborated into unnecessary detail. The method of determining insoluble fatty acids appears to be more objectionable than any other part of the scheme. The method of making the melting point first described in the *Journal of Analytical Chemistry* (vol. 1, No. 1, p. 39) appears to have escaped the notice of the German commission. I also note with regret the apparent ignorance of the existence of the Gooch crucible existing in Germany.

Points to be especially commended in these investigations are, sending samples and standard re-agents, blanks for entering the analytical results, and minute printed directions for conducting the manipulation.

The numbers prefixed to the several paragraphs correspond to the number of the column in the blank in which the results are to be entered.—H. W. W.

CRITICISM OF WOLLNY'S METHODS.

Goldmann criticises Wollny's original method chiefly because it gives only a part of the volatile acid present and takes no account of the whole. It has never been claimed, however, for the Reichert process that it gave anything more than a portion of the volatile acid present, but the percentage of the total volatile acids obtained is approximately constant, and therefore the results are comparable among themselves.

Goldmann proposes to remove the last traces of alcohol after saponification by distillation in a current of steam. Before the distillation of any part of the alcohol, however, the solution is heated with a reflux condenser for half an hour so that any ethers which have been formed may be recombined by the excess of alkali present. The apparatus for the removal of the last traces of alcohol is illustrated in No. 14 of the *Chemiker-Zeitung* for 1888, page 216.

Goldmann's paper is so long that for all details I can only refer to the original. The method finally adopted by him is as follows: 5 grams of the melted butter fat are weighed in a flask of 300 cubic centimeters capacity, the neck of which is 12 centimeters long and 2 centimeters wide. Add 10 cubic centimeters alcohol, 96 per cent., and 2 cubic centimeters of a 50 per cent. aqueous soda lye made and preserved out of contact with carbonic acid. The flask, furnished with a reflux condenser, is heated for twenty minutes with a small flame. The condenser is turned to an angle of 55° and 6 cubic centimeters of the alcohol distilled off. The flame is then extinguished, the apparatus connected with the flask delivering steam and the whole of the alcohol driven off by a slow current of steam.

Full directions for the conduct of this part of the work are given by Goldmann.

After the alcohol is driven off the soap is decomposed by the addition of 5 cubic centimeters of sulphuric acid containing 200 cubic centimeters of strong acid to the liter. The volatile acids are distilled off in a current of steam and 600 cubic centimeters of distillate taken which is titrated with one-tenth normal solution of barium hydrate.—(Abstract from *Chemiker-Zeitung* 1888, No. 12, p. 183; No. 14, p. 216; No. 20, p. 317.)

APPLICATION OF THE REICHERT-MEISSL-WOLLNY METHOD TO ITALIAN BUTTERS.

Besana has made an extended examination of 114 samples of butter, and from the study of them draws the following conclusions:

One hundred and fourteen samples of butter examined belong to 30 provinces. These show a melting-point from a minimum of 33° C. to a maximum of 37.7°, not including one sample which seems to be essentially different in constitution. No positive relation has been established between the point of fusion and the quantity of volatile acids; therefore the knowledge of the first offers no special utility.

The percentage of volatile acids, or the quantity of the same expressed in cubic centimeters of deci-normal alkaline solutions, shows a variation from a minimum of 21.83 to a maximum of 30.19. The classification of the 114 samples of butter, according to their quality or condition, would be as follows:

Volatile acids from	No. samples.
29 to 30.19	23
28 to 29	25
27 to 28	49
26 to 27	9
25 to 26	3
24 to 25	2
23 to 24	1
21.80 to 22	2
	114

The variation in the quantity of the volatile acids, in the different butters, already recognized by various experimenters in Germany and Sweden, is confirmed by these researches also in the Italian butters. Even the butters of the same dairy may present quite different qualities, although made within a very few days of each other. Upon the cause of this variability I have not ventured, up to the present time, to present any theory, and I have not even sufficient data for the support or contradiction of the theories of others. I hold the causes to be biological, and I would like the researches tending to their discovery to be made by following very closely the chemistry of nutrition and of the lacteal secretions or the transformation of aliment into milk, keeping note of the quantity and quality of the food, the stage of lactation, the condition of health in the animal, etc.; but such researches, in my opinion, should be followed upon individual cases, instead of upon a group of milch cows.—(Prof. Carlo Besana, extract from the journal "*Le Stazioni Sperimentali Agrarie Italiane*," 1888, Vol. XIV.)

The report being open to discussion, inquiries were made as to the cost of the lactocrite. Professor Myers stated that when adapted to the ordinary De Laval separator it cost \$125, and could be obtained from the De Laval separator Company, 221 Dock street, Philadelphia, Pa. If it were necessary to purchase the separator frame in addition, the cost would probably reach nearly \$250.

In regard to the cost of the lactocrite, I would say that I recently secured one for the West Virginia Experiment Station for \$125 from the De Laval Separator Company of Philadelphia.

It is arranged in such a way that it can be set in the place of the drum of the separator and run by the power that runs the latter. The construction is very simple, and for the rapid testing of milk it appears to be the most satisfactory method yet devised.

There is likewise an apparatus provided by the same company which is intended to mix artificial fats with the skimmed milk. It is arranged so that the liquid fat and the skimmed milk are violently whipped together, the fat being delivered in a finally, divided condition.

I have been suspicious for a considerable time that much of the cream now in the market is cream manufactured in this or some similar manner, and, as we have ordered one of these machines for the experiment station, we propose in the near future to see to what extent we can mix fat of cotton, pig, or cow with skimmed milk to supply the gastronomic needs of our national capital.

Mr. Richardson then made the following remarks on the milks found on sale in Washington, D. C.:

THE MILK OF WASHINGTON NOT NORMAL.

During the past year complaint and observation having led me, as Chemist of the District, to believe that the milks of the city were not of that quality which are found in other cities, where a thorough inspection and milk control are carried on, I have made an examination of eleven samples from the principal dairies and milk routes of the town, and the results are presented here with the view of showing the value of the table of normal relation of fat to specific gravity and solids as given by Hehner and Richmond, for detecting milks which have been tampered with in some one of the several ways now in common vogue.

The method of determining specific gravity was that of the pycnometer, controlled by the spindle, at the standard temperature 15° C. Solids were determined on asbestos fiber in nickel dishes at 100° C. for one hour after drying on the steam-bath. Fat was determined with previously, extracted paper coils and Squibbs ether.

The results were as follows:

No.	Dairies and milk routes.	Specific gravity.	Solids.	Solids not fat.	Fat.	Normal fat.
508	First street, between Pennsylvania avenue and B street, northwest, small grocery	1.0288	13.54	8.93	4.61	5.38
515	Wise's dairy	1.0334	11.88	7.67	3.71	2.38
516	Fairfax dairy	1.0341	11.68	7.88	3.80	2.59
528	Alpha dairy, 811 North Capitol street	1.0308	12.45	8.48	3.97	3.95
529	Small grocery, Four-and-a-half street, between Pennsylvania avenue and C street	1.0297	11.53	8.14	3.39	3.44
530	Fort Baker dairy, Third street and Indiana avenue	1.0320	11.79	8.73	3.06	3.10
531	Russell's dairy, Third and C streets	1.0296	10.71	7.43	3.28	2.74
538	Excelsior dairy, 1757 Pennsylvania avenue	1.0292	11.46	8.08	3.38	3.47
539	Thompson's dairy, 511 Four-and-a-half street, southwest	1.0311	12.47	8.59	3.88	3.93
540	Floral Hill dairy	1.0270	9.87	7.33	2.54	3.49
541	F. K. Ward's wagon	1.0343	11.39	8.31	3.08	2.31
	Average		11.66	8.15	3.51	.....

The milks were collected between March 23 and 30. Of the eleven samples, but three were at all near the standard which would allow their sale in Massachusetts, New York, or New Jersey, and of these three but two were normal in composition. Of the entire eleven only six were normal, according to the tables, these showing a very close agreement with theory, while the other five were so extremely discordant

as not to permit of errors of analysis. The normal milks agreed remarkably well, as may be seen from the following figures:

Fat found by analysis.	Fat calculated for normal milk.	Difference.
3.97	3.95	+ .02
3.39	3.44	-.05
3.06	3.10	-.04
3.38	3.47	-.09
3.88	3.95	-.07
2.54	2.49	+ .05

These figures certainly show the tables of Hehner & Richmond to be equally applicable to American and continental milks.

The differences in the remainder of the milks were as follows:

Fat found by analysis.	Fat calculated for normal milk.	Difference.
4.61	5.36	-.75
3.71	2.38	+1.33
3.80	2.59	+1.21
3.25	2.74	+.54
3.08	2.31	+.77

In all but one case an excess of fat was found, which leads to the belief that oleo oil or similar substance had been churned into the milk to enrich a poor or skim milk, the difference being, it seems to me, altogether too large and striking, after the coincidences found in the other samples, to make it readily supposed that the samples were normal in character.

The extremely poor character of the milks of this city point to the necessity of milk inspection, even if this is due to low-grade cattle and poor feed alone; and it would seem that the tables given by Dr. Wiley may prove of great value in pointing out suspicious milks for further examination.

Dr. Wiley spoke of Hehner & Richmond's recommending the rejection of all analyses not agreeing with their tables as erroneous, and said that this was certainly very dogmatic, as on adulterated milks such agreement is impossible.

Mr. Richards spoke of Swedish machines for taking out cream and putting back cotton-seed oil, illustrated in *London Engineering*.

Professor Meyers spoke of the methods of emulsifying oil and skim-milk and its frequency. Cotton-seed oil can be switched in for calf feed, but he did not think artificial cream can be made so. Oleo oil is probably used.

The secretary then read the following communication from Professor G. E. Patrick, of Iowa:

NOTES ON THE METHOD FOR SOLUBLE AND INSOLUBLE FAT ACIDS.

In the determination of soluble and insoluble fat acids I have recently found it convenient, as well as economical of time and material, to change slightly the mode of procedure as laid down in the method (originally Muter's) adopted by this association at its last meeting (1887) and published in Bulletin No. 16 from the Department of Agriculture, Chemical Division, pages 70 and 71.

The purpose of the modification is to avoid the use of a separate saponifying bottle, and the consequent transfer of the soap solution to an Erlenmeyer flask, and evaporation of the alcohol added in this transfer.

This end is accomplished by saponifying directly in the Erlenmeyer, the latter (with stopper tied down) being inclosed in a "conversion" jar with tight cover, and containing absolute alcohol (50 cubic centimeters), the vapor of which gives an outside pressure on the Erlenmeyer equal to that within. The jar is made with vertical sides, and is only a little larger than the flask it is to inclose; its cover is held down by a screw-clamp in the usual way, a disc or washer of rubber making the union tight.

Breakage by contact of the flask with the walls of the jar while agitating is prevented by a ring of corks strung upon a wire. Thus arranged, *with a tight jar*, there is no danger of breaking the Erlenmeyer if the work is executed with ordinary care. Fifty cubic centimeters of absolute alcohol in the jar will suffice for many analyses.

Two styles of jar have been tried, one of heavy glass, iron bound (made by Eimer Amend), the other of heavy sheet copper, made (excepting the clamp) by an ordinary tinsmith; the cover of each is a thick ground-glass plate, with a metal disk to receive the pressure of the screw. The glass one, allowing a view of the interior during saponification, is the more convenient.

The saponification is conducted in a steam or air oven at a few degrees below 100 centimeters. Neither style of jar can be heated directly on the water or steam bath with safety to the contents. This needs further trial.

Another slight deviation from the method of last year, which I find convenient, is to retain the cake of insoluble acids in the Erlenmeyer for weighing, using alcohol merely to dissolve into the flask whatever fat acids are on the dried filter. This small amount of alcohol is quickly removed, first on the water bath and then in the oven, with a current of dry air or hydrogen.

By these two changes in the method the entire determination of insoluble acids is effected without any transfer of material from first to last. At the start the filtered, still liquid, and well-shaken fat is weighed into the tared Erlenmeyer; at the end, after the insoluble acids are weighed, they are removed and the flask is dried and tared again to insure against error from "nicking" or corrosion during the operation. However, in the few trials thus far made, the first and last weights of the flask have been practically identical.

The report of the committee was then adopted.

Dr. W. J. Gascoyne then read the report of the Committee on Phosphoric Acid, the president stating that, at the request of the Executive Committee, Dr. Gascoyne had retained the position of chairman on his resignation as State chemist of Virginia.

REPORT OF THE COMMITTEE ON PHOSPHORIC ACID.

As required by the constitution of the association, the Committee on Phosphoric Acid herewith presents its report. The report presents: 1, brief notices of new analytical methods for determining phosphoric acid proposed during the year; 2, results of work done by the committee and members of the association; 3, recommendations for the next year.

C. Mohr (Chem. Zeit., 11, 417-418; Abs. J. Chem. Soc., 1887, p. 884) proposes the following volumetric method for phosphoric acid: Two grams of the phosphatic substance is treated with successive small quantities of 2 per cent. sulphuric acid in a mortar. The residue is added to the extracts, and the whole made up to 100 cubic centimeters and allowed to digest for one hour; 10 cubic centimeters of the filtered solution, corresponding to 0.2 grams, are then treated with potassium ferrocyanide so long as iron is precipitated. After the addition of sodium acetate, the phosphoric

acid is titrated in the usual way with a standard solution of uranium acetate. It is stated that the end reaction is not influenced either by an excess of potassium ferrocyanide or by the presence of Prussian blue.

G. Kennepohl (Chem. Zeit., 11, 1089-1091; Abs. J. Chem. Soc., 1888, 321; J. Soc. Chem. Ind., 6, 680) confirms the opinion expressed by Klein (Chem. Zeit., 10, 721; J. Chem. Soc., 1886, 835) as to the practical non-occurrence of iron phosphide in normal Thomas slag. The phosphoric acid may be accurately determined in the following manner: Ten grams of the finely powdered slag are introduced into a 500 cubic centimeter flask, moistened with alcohol to prevent adhesion, and heated in a water bath for at least half an hour with 40 cubic centimeters of HCl. (1.12 sp. gr.) and 40 cubic centimeters of water. After cooling the flask is filled to the graduation mark and the solution filtered. An aliquot part is mixed with ammonium nitrate and molybdic solution without previous removal of the silica. The solution, after heating at about 80° for fifteen minutes, is filtered, and the precipitate washed with water containing 3 per cent. of nitric acid, redissolved in 2½ per cent. ammonia, and then precipitated with magnesia mixture. The presence of silica does not interfere, owing to the ready solubility of ammonium silico-molybdate in the washing water.

If the presence of ferrous salts should tend to cause the separation of molybdic oxide, which dissolves but slowly in ammonia, an addition of nitric acid or bromine, before adding the molybdic solution, will insure the production of a precipitate in stantaneously soluble in the ammonia.

Isbert and Stutzer (Zeit. Anal. Chem., 26, 583-587; Abs. J. Chem. Soc., 1888, 194; Chem. News, 57, 211; J. Soc. Chem. Ind., 7, 44; J. Anal. Chem., 2, 193). The method based on the determination of the ammonia in the phospho-molybdate precipitate (Chem. Zeit., 11, 223) is confirmed. A further simplification consists in washing the yellow precipitate with cold water, instead of with ammonium nitrate solution. The ammonium silico-molybdate is soluble in pure cold water, although insoluble in ammonium nitrate solution. On the other hand, the phospho-molybdate requires 10,000 parts of cold water for its solution.

The analysis is conducted as follows :

Five grams of the phosphate are dissolved in hydrochloric acid or aqua-regia, diluted to 500 cubic centimeters and filtered. Fifty centimeters of the filtrate are mixed with an excess of ammonia, acidulated with nitric acid, and the phosphoric acid precipitated with ammonium molybdate. The precipitate is allowed to settle at 60° to 70° C. for fifteen minutes, and then filtered, the supernatant liquid being first passed through the filter, the precipitate repeatedly washed by decantation, then placed upon the filter and washed with water until the wash water amounts to about 250 cubic centimeters. The precipitate is transferred, filter and all, to a ½-liter Erlenmeyer flask, sodium hydroxide added in excess, and the ammonia distilled off into a solution of standard acid, which is then titrated back with baryta water, using rosolic acid as the indicator.

One part of nitrogen in the precipitate corresponds with 1.654 parts of phosphoric acid.

Test analyses with known quantities of phosphate, with and without silicic acid, and comparative tests of phosphatic manures by the above and gravimetric process, show that for commercial purposes the method is sufficiently accurate.

Ch. Malot (Monit. Scient., 1887, 487; J. Pharm., 16, 157-159; J. Chem. Soc., 1887, 1063; J. Soc. Chem. Ind., 6, 563) describes a new volumetric method for P_2O_5 by uranium nitrate. Oxide of uranium gives a green lake with cochineal, which property is utilized for the determination of phosphoric acid.

The phosphate is treated according to Jonlie's method, i. e., dissolved in HCl, the phosphoric acid precipitated with citro-magnesium mixture and the precipitate dissolved in dilute nitric acid. A few drops of tincture of cochineal are added, then ammonia until the violet coloration just appears, and this in its turn is made to disappear with one to two drops of nitric acid. The solution is now heated to 100° C.,

5 cubic centimeters of sodium acetate solution added and mixture titrated with uranium nitrate. Each drop of the latter causes a greenish-blue zone, which, on agitation, disappears again. As soon as precipitation is complete, the solution assumes a lasting greenish-blue color, remaining unchanged by excess of the uranium solution. The end reaction is most distinct. By employing a very dilute solution of uranium nitrate, the determination is rendered very exact. The author uses solutions, 1 cubic centimeter of which represents 0.002 gram of phosphoric acid.

A. Emmerling (Zeits. Anal. Chem., 26, 244, Abs. Chem. News, 57, 15; J. Anal. Chem., 2, 228) describes a new method for the determination of soluble phosphoric acid in superphosphates.

The solution of superphosphates, mixed with calcium chloride, is allowed to flow into a standardized solution of caustic soda, to which some phenolphthalein has been added. The following solutions are required:

- (1) Sodium hydrate, of which 1 cubic centimeter represents about .005 P_2O_5 .
- (2) Calcium chloride solution made by dissolving 200 grams $CaCl_2$ in one liter of water.
- (3) Phenolphthalein, 1 gram in 500 cubic centimeters of alcohol.
- (4) Methyl orange in aqueous solution.

The execution of an analysis is carried on as follows:

Two hundred cubic centimeters of the solution of the sample prepared in the ordinary manner are well mixed with 50 cubic centimeters solution of calcium chloride. One burette is filled with this mixed solution and a second with the soda solution. Of this latter 20, 10, or 5 cubic centimeters (according to the strength of the superphosphate) are measured into a beaker; 2 cubic centimeters of the phenolphthalein solution are added, and some water, and the superphosphate solution is then run rather rapidly. As soon as the color begins to grow faint the superphosphate liquor is added more gradually, and at last drop by drop, until the redness has entirely disappeared.

The author next measures off again the same number of cubic centimeters of the mixed solution of superphosphate and calcium chloride as used above, dilutes with a little water and mixes with 4 to 6 drops of the methyl orange solution. The liquid is titrated cautiously with the soda solution, finally drop by drop until the reddish color changes to a yellow or orange yellow.

The smaller number of cubic centimeters of soda solution, as consumed in the titration with methyl-orange, is deducted from the number obtained on titrating with phenolphthalein. If we have dissolved 20 grams superphosphate in 1,000 cubic centimeters of water, and make up 200 to 250 cubic centimeters by the addition of 50 cubic centimeters of the calcium chloride solution, and if a is the measured quantity of soda, b the solution of superphosphate and calcium chloride consumed, c the soda used for neutralizing the free acid, and t the standard of the soda expressed as P_2O_5 , the percentage of soluble phosphoric acid in the sample is equal to

$$a - c \times t \times \frac{250 \times 1000 \times 100}{200 \times 6.20}$$

This method is applicable to ferruginous superphosphates.

J. Ruffe (J. Soc. Chem. Ind., 6, 327-333; Abs. J. Chem. Soc., 1888, p. 87; J. Anal. Chem., 1, p. 455) has contributed an interesting paper on moisture and free acids in superphosphate. The loss of moisture, dried to constant weight, at various temperatures varied in one sample from 12.92 per cent. at 38° to 50° C., to 17.93 per cent. at 150° C. Drying at the same temperature, 100° C., for different periods, showed a variation of from 9.97 per cent. for thirty minutes, to 17.15 per cent. for seven hours. The fertilizer dried in its natural state, at 100° C., showed a much greater loss of moisture than when previously rubbed to a fine paste in a mortar.

It is also shown that the soluble phosphoric acid existing in superphosphates is not entirely present as mono-calcium phosphate, and that the exposure of 100° C. drives

off more than the true moisture, that is, the adhering uncombined water. It is recommended to determine the moisture in the following manner: Weigh out 2 to 5 grams of the phosphate in its natural state on a double watch glass, place under an air pump over dry calcium chloride, exhaust, then leave for eighteen to twenty-four hours and weigh.

John Clark (*J. Soc. Chem. Ind.*, 7, 311-312) describes a modification of Perrot's (*Compt. Rend.*, 93, 495) for the estimation of phosphoric acid as phosphate of silver.

The objection to Perrot's process, when applied to manures and natural phosphates, are—

(1) The chlorides which may be present will be estimated as phosphates.

(2) The method of separating the phosphates of iron and alumina from the phosphates of lime and magnesia is inaccurate, as it is practically impossible to dissolve out the whole of the phosphate of lime in the manner indicated.

The modifications which the author recommends are—

(1) The solution of the phosphate of silver precipitate in nitric acid, and the titration of the silver with sulpho-cyanide.

(2) The neutralization of the acid solution with caustic soda instead of ammonia, to avoid the presence of an excessive quantity of ammoniacal salt, which affects the results.

(3) The previous precipitation of the iron and alumina as phosphate with acetate of soda containing free acetic acid.

The following is an outline of the process: The phosphate is dissolved either in water, nitric acid, or sulphuric acid, the greater portion of the free acid neutralized with caustic soda, and to the cold solution acetate of soda containing free acetic acid is added in excess. If the addition of the acetate of soda produces a precipitate, this must be filtered off, re-dissolved, and re-precipitated with acetate of soda, as before. The filtrate and washings are added to the previous filtrate, then excess of nitrate of silver, which will give an immediate precipitate of phosphate of silver, Ag_3PO_4 , and the free acetic acid is neutralized with caustic soda till there is only a faint acid reaction to litmus paper.

The slightest excess of caustic soda will cause a brown precipitate of oxide of silver, but this oxide of silver dissolves easily on the addition of a few drops of dilute acetic acid.

The precipitate of phosphate of silver, which will contain any chloride which may have been present, is thrown on a filter, thoroughly washed with water, then dissolved off the filter with hot dilute nitric acid, mixed with a little ferric sulphate, and the silver titrated with sulpho-cyanide, as described by Volhard, and calculated to phosphoric acid.

The precipitate of phosphate of iron and alumina is dried, ignited, and weighed, then dissolved in acid, the iron determined volumetrically, calculated to phosphate of iron, and the balance assumed to be phosphate of alumina; or the oxide of iron may be separated with caustic soda and the alumina in the filtrate weighed as phosphate of alumina, using the precautions recommended by Thomson (*J. Soc. Chem. Ind.*, vol. 5).

Comparative tests on a variety of materials show a close agreement with the molybdic method.

Dircks and Werenskiöld (*Landw. Versuchs. Stat.*, 1887, 425-453; *Abs. J. Chem. Soc.*, 1888, 628) have tested the various processes employed for the estimation and separation of tri-calcium from mono- and di-calcium phosphate, namely, the various modifications of the ammonium citrate method. They find that although none of the methods give a really satisfactory and exact result, Petermann's process is perhaps the most trustworthy.

C. Schindler (*Zeits. Anal. Chem.*, 27, 142-146; *J. Chem. Soc.*, 1888, 753, *J. Soc. Chem. Ind.*, 7, 455) describes a volumetric method for the determination of phosphoric acid

based upon the formation of a compound of phospho-molybdate of ammonia of definite composition.

The following solutions are requisite:

(1) *Molybdic solution*.—To a liter of molybdic acid solution prepared in the usual manner, 30 cubic centimeters of a solution of citric acid containing 500 grams to the liter are added.

(2) Concentrated ammonium nitrate solution containing 750 grams to the liter.

(3) Dilute ammonium nitrate solution containing 100 grams to the liter and 10 cubic centimeters nitric acid.

(4) Magnesia mixture prepared in the usual manner.

(5) Lead solution, 1 cubic centimeter of which corresponds to .04 grams P_2O_5 . This is obtained by dissolving 55 grams lead acetate in one liter of water and a little acetic acid.

(6) Molybdate of ammonium solution, 1 cubic centimeter of which corresponds to 1 cubic centimeter lead solution; 25 grams ammonium molybdate are dissolved in one liter and standardized against the lead solution.

(7) Tannin solution, 1 gram tannin is dissolved in 20 to 30 cubic centimeters of water.

The analysis is conducted as follows: 50 cubic centimeters of the nitric acid solution of the phosphate (0.5 gram of substance) is mixed with so much of the concentrated solution of ammonium nitrate that after the addition of the molybdic acid solution the mixture shall contain 25 grams ammonium nitrate per 100 cubic centimeters. Then for each 0.1 gram of P_2O_5 , 100 cubic centimeters of the molybdic acid solution is added, and the mixture heated in a water bath to about 58° C. The precipitate is allowed to settle for ten minutes, and the liquid decanted and passed through a filter. The precipitate is washed with 50 cubic centimeters dilute ammonium nitrate solution by decantation, and dissolved in 3 per cent. ammonia solution. The solution, together with that dissolved off the filter, is brought into a quarter-liter flask, 10 to 20 cubic centimeters magnesia mixture added; after shaking, it is made up to 250 cubic centimeters and filtered. Fifty cubic centimeters of the filtrate are taken, acidified with acetic acid, and the liquid made up with boiling water to 300 cubic centimeters. Lead solution is now added from a burette until a small excess of lead goes into solution, and is titrated back with ammonium molybdate solution, using the tannin solution as an indicator. A drop of tannin solution gives a red coloration with ammonium molybdate, which is visible in a solution of 1 in 400,000, whereas lead molybdate gives no coloration; and lead acetate only a greenish coloration.

Comparative determinations on a variety of materials show a close agreement with the magnesia method.

At a meeting of the directors of the Belgian experiment stations, the following method for the estimation of the phosphoric acid soluble in water and in citrate of ammonia in manures was adopted:

Two grams of ordinary superphosphate (or one gram of a rich sample, say over 20 per cent.) are triturated in a mortar with water and thrown upon a filter. The filter is washed with water until about 200 cubic centimeters have passed through; to the filtrate is added 1 cubic centimeter of nitric acid, and the volume of the solution is made up to 250 cubic centimeters. The filter, and the insoluble matter contained in it, is now introduced into a 250 cubic centimeters flask with 50 cubic centimeters of Petermann's alkaline citrate of ammonia solution, and allowed to digest for one hour on the water bath at a temperature of 38° to 48° C. After rapidly cooling the flask is filled up to the mark with water. Of the above filtered liquid (the citrate of ammonia solution), take 50 cubic centimeters and mix it with 50 cubic centimeters of the aqueous solution, acidify with nitric acid and precipitate with molybdic acid solution. The remainder of the operations remain as for the ordinary estimation of phosphoric acid.

Petermann's alkaline citrate of ammonia is prepared by dissolving 500 grams of cit-

ric acid crystals in water and mixing with 700 cubic centimeters of ammonia of 0.920 specific gravity. Bring the concentration of the liquid to 1.09 specific gravity at 15° C., and add to each liter 50 cubic centimeters ammonia of .920 specific gravity.

RESULTS OF WORK DONE DURING THE YEAR.

Last October your committee sent to nineteen official and seventeen commercial chemists five samples for phosphoric acid determination, with the request that the determinations be made within the week ending October 29.

The samples were marked as follows:

- No. 1. Ground South Carolina phosphate.
- No. 2. Ground tankage.
- No. 3. Ammoniated superphosphate.
- No. 4. Dissolved South Carolina phosphate.
- No. 5. Dissolved Navassa phosphate.

The samples were carefully mixed, so as to secure uniformity.

Returns have been received from twenty-seven laboratories, covering the work of thirty-two chemists. The results are given in the following tables:

No. 1 and No. 2.

Analyst.	No. 1—South Carolina phosphate.		No. 2—Tankage.	
	Moisture.	Phosphoric acid.	Moisture.	Phosphoric acid.
E. H. Farrington, Connecticut experiment station.....		27. 67		14. 89
T. B. Osborne, Connecticut experiment station.....		27. 85		14. 30
A. L. Winton, Connecticut experiment station.....		27. 89		14. 33
J. P. Carson, Richmond, Va.....		28. 14		13. 95
C. Glaser, Baltimore, Md.....	. 78	28. 30	6. 78	14. 01
W. J. Gascoyne, Baltimore, Md.....	. 93	28. 14	6. 66	14. 20
Lehmann & Mager, Baltimore, Md.....	. 80	28. 78	6. 03	14. 52
C. C. Read, New Bedford, Mass.....		27. 80		14. 91
B. Terne, Philadelphia, Pa.....		27. 68		14. 24
Rasin Fertilizer Company, Baltimore, Md.....	. 95	28. 20	6. 88	14. 02
P. B. Wilson, Baltimore, Md.....	. 94	28. 22	6. 94	14. 06
R. H. Gaines, Richmond, Va.....		28. 30		14. 71
J. M. Bartlett, experiment station, Orono, Me.....	. 92	28. 00	7. 14	13. 89
N. H. Merrill, experiment station, Orono, Me.....	. 92	27. 87	7. 14	14. 00
W. Frear, State College, Pa.....	1. 37	27. 84	7. 04	14. 40
Clifford Richardson, Washington, D. C.....		27. 67		14. 87
Stillwell & Gladding, New York.....	1. 08	28. 33	7. 00	14. 59
C. E. Buck, Wilmington, Del.....		27. 98		14. 50
W. Robertson, Charleston, S. C.....	. 83	28. 40	6. 55	14. 71
M. A. Soovell, Kentucky experiment station.....	1. 02	27. 87	6. 16	14. 41
A. M. Peter, Kentucky experiment station.....	1. 00	27. 84	6. 26	14. 16
H. B. Battle, North Carolina experiment station.....	1. 04	28. 22	7. 08	14. 32
A. F. Shireick, Wood's Holl, Mass.....		28. 34		14. 03
N. W. Lord, Columbus, Ohio.....	. 97	27. 47	7. 35	14. 06
W. McMurtrie, Champaign, Ill.....		27. 37		14. 13
A. E. Knorr, Department of Agriculture, Washington.....	. 76	28. 16	6. 44	14. 23
J. M. McCandless, Atlanta, Ga.....	1. 05	27. 78	6. 70	14. 16
H. Froehling, Richmond, Va.....		28. 08		13. 62
P. E. Chazal, Columbia, S. C.....	. 80	28. 91	6. 70	14. 75
Bradley Fertilizer Company (Benson), Boston.....		27. 65		14. 91
Bradley Fertilizer Company (Patrick), Boston.....		28. 40		14. 35

No. 3.—Ammoniated superphosphate.

Analyst.	Moisture.	Soluble phosphoric acid.	Reverted phosphoric acid.	Available phosphoric acid.	Insoluble phosphoric acid.	Total phosphoric acid.
E. H. Farrington, Connecticut experiment station.	14.59	7.02	1.52	8.54	1.40	9.94
T. B. Osborne, Connecticut experiment station.	14.82	7.12	.95	8.07	1.84	9.91
A. L. Winton, Connecticut experiment station.		7.11	1.25	8.36	1.36	9.72
J. F. Carson, Richmond, Va.	17.21	7.38	1.39	8.77	1.64	10.41
C. Glaser, Baltimore, Md.	16.60	6.75	1.41	8.16	1.62	10.04
W. J. Gascoyne, Baltimore, Md.	17.15	7.08	1.76	8.84	1.89	10.23
Lehmann & Mager, Baltimore, Md.	14.05	7.16	1.35	8.51	1.79	10.30
C. C. Read, New Bedford, Mass.	12.00	8.57	1.03	9.60	1.89	11.49
B. Terne, Philadelphia, Pa.	14.81	7.16	1.55	8.71	1.72	10.43
Rasin Fertilizer Company, Baltimore, Md.	16.40	7.00	1.05	8.05	2.20	10.25
P. B. Wilson, Baltimore, Md.	16.88	7.03	1.02	8.05	2.17	10.22
R. H. Gaines, Richmond, Va.		7.19	1.14	8.33	2.00	10.33
J. M. Bartlett, experiment station, Orono, Me.	12.87	7.10	1.34	8.44	1.49	9.93
S. H. Merrill, experiment station, Orono, Me.	12.87	7.01	1.58	8.59	1.38	9.97
W. Frear, State College, Pa.	18.36	6.00	2.27	8.27	1.60	9.87
Clifford Richardson, Washington, D. C.	18.10	7.49	.80	8.29	1.59	9.88
Stillwell & Gladding, New York.	14.30	7.15	1.22	8.37	1.73	10.10
C. E. Buck, Wilmington, Del.		7.00	1.36	8.36	1.44	9.80
W. Robertson, Charleston, S. C.	15.70	7.29	1.49	8.78	1.58	10.36
M. A. Scovell, Kentucky experiment station.	13.91	6.97	1.17	8.14	1.78	9.92
A. M. Peter, Kentucky experiment station.	13.88	7.09	1.27	8.36	1.56	9.92
H. B. Battle, North Carolina experiment station.	14.39	7.02	.93	7.95	1.78	9.73
A. F. Shireick, Wood's Holl, Mass.	16.50	7.00	1.27	8.27	1.52	9.79
N. W. Lord, Columbus, Ohio.	19.65	7.02	1.42	8.44	1.40	9.84
W. McMurtrie, Champaign, Ill.		7.07	1.78	8.85	1.45	10.30
A. E. Knorr, Department of Agriculture, Washington	14.06	6.74	1.59	8.33	1.30	9.63
J. M. McCandless, Atlanta, Ga.	12.95	7.14	1.20	8.34	1.35	9.69
W. W. Cooke, Burlington, Vt.		6.99	.93	7.92	1.82	9.74
H. Froehling, Richmond, Va.		7.19	1.26	8.45	1.52	9.97
P. E. Chazal, Columbia, S. C.	15.95	7.45	1.26	8.74	1.56	10.30
Bradley Fertilizer Company (Benson), Boston.		7.20	.99	8.19	1.81	10.00
Bradley Fertilizer Company (Patrick), Boston.		7.04	1.22	8.26	2.00	10.26

No. 4.—Dissolved South Carolina phosphate.

Analyst.	Moisture.	Soluble phosphoric acid.	Reverted phosphoric acid.	Available phosphoric acid.	Insoluble phosphoric acid.	Total phosphoric acid.
E. H. Farrington, Connecticut experiment station.	9.57	10.95	3.18	14.13	1.47	15.60
T. B. Osborne, Connecticut experiment station.	9.57	11.04	2.88	13.92	1.77	15.69
A. L. Winton, Connecticut experiment station.		11.03	3.26	14.29	1.32	15.61
J. F. Carson, Richmond, Va.	9.77	8.67	5.21	13.88	2.26	16.08
C. Glaser, Baltimore, Md.	9.69	11.02	3.13	14.15	1.82	16.17
W. J. Gascoyne, Baltimore, Md.	9.41	11.03	8.23	14.26	1.73	15.99
Lehmann & Mager, Baltimore, Md.	9.28	11.00	3.07	14.07	2.11	16.18
C. C. Read, New Bedford, Mass.	9.03	11.30	2.84	14.14	1.76	15.90
B. Terne, Philadelphia, Pa.	9.76	10.81	2.68	13.49	2.59	16.08
Rasin Fertilizer Company, Baltimore, Md.	10.00	11.02	3.20	14.22	1.96	16.18
P. B. Wilson, Baltimore, Md.	10.07	11.00	3.24	14.24	1.90	16.14
R. H. Gaines, Richmond, Va.		11.51	2.24	13.75	2.24	15.99
J. M. Bartlett, experiment station, Orono, Me.	9.12	10.93	2.45	13.38	2.08	15.46
S. H. Merrill, experiment station, Orono, Me.	9.12	10.76	3.18	13.94	1.70	15.64
W. Frear, State College, Pa.	10.42	10.84	3.26	14.10	1.70	15.80
Clifford Richardson, Washington, D. C.	11.14	11.23	2.28	13.51	2.13	15.64
Stillwell & Gladding, New York.	9.53	10.82	3.03	13.85	2.15	16.00
C. E. Buck, Wilmington, Del.		10.84	3.41	14.23	1.34	15.59
W. Robertson, Charleston, S. C.	9.40	11.26	2.55	13.81	2.12	15.83
M. A. Scovell, Kentucky experiment station.	9.65	10.73	2.73	13.46	1.97	15.43
A. M. Peter, Kentucky experiment station.	9.55	10.82	2.82	13.64	1.75	15.39
H. B. Battle, North Carolina experiment station.	9.20	10.84	2.24	13.18	2.19	15.37
A. F. Shireick, Wood's Holl, Mass.	9.58	10.87	3.31	14.18	1.40	15.56
N. W. Lord, Columbus, Ohio.	9.53	10.73	3.01	13.74	1.72	15.46
W. McMurtrie, Champaign, Ill.		11.16	1.21	12.87	2.81	15.18
A. E. Knorr, Department of Agriculture, Washington	9.33	10.63	3.31	13.94	1.28	15.22
J. M. McCandless, Atlanta, Ga.	9.60	10.50	3.12	13.62	2.28	15.90
W. W. Cooke, Burlington, Vt.		10.70	2.69	13.39	2.24	15.63
H. Froehling, Richmond, Va.		11.18	2.75	13.93	1.68	15.61
P. E. Chazal, Columbia, S. C.	9.40	11.32	2.55	13.87	1.99	15.86
Bradley Fertilizer Company (Benson), Boston.		10.80	2.30	13.10	2.31	15.41
Bradley Fertilizer Company (Patrick), Boston.		11.00	2.54	13.54	2.66	16.20

No. 5.—Dissolved Navassa phosphate.

Analyst.	Moisture.	Soluble phosphoric acid.	Reverted phosphoric acid.	Available phosphoric acid.	Insoluble phosphoric acid.	Total phosphoric acid.
E. H. Farrington, Connecticut experiment station ..	9.29	8.00	7.38	15.38	3.18	18.56
T. B. Osborne, Connecticut experiment station	9.20	8.60	7.21	15.21	3.22	18.43
A. L. Winton, Connecticut experiment station .....	.....	7.93	7.62	15.35	3.02	18.37
J. P. Carson, Richmond, Va	9.68	6.78	8.78	15.66	3.39	18.95
C. Glasor, Baltimore, Md	10.35	6.36	8.82	15.18	3.41	18.59
W. J. Gascoyne, Baltimore, Md	9.15	7.38	7.78	15.10	3.33	18.49
Lehmann & Mager, Baltimore, Md	8.72	6.78	8.69	15.67	3.52	19.19
C. C. Read, New Bedford, Mass	8.09	7.90	7.27	15.17	3.20	18.37
B. Torne, Philadelphia, Pa	9.63	6.91	8.44	15.35	3.77	19.12
Rasin Fertilizer Company, Baltimore, Md	10.40	6.05	8.62	14.67	3.86	18.53
P. B. Wilson, Baltimore, Md	10.35	6.00	8.62	14.62	3.81	18.43
R. H. Gainca, Richmond, Va .....	.....	7.52	7.67	15.19	3.52	18.71
J. M. Bartlett, experiment station, Orono, Me ..	8.65	8.05	6.93	14.98	3.61	18.59
S. H. Merrill, experiment station, Orono, Me	8.65	7.68	7.36	15.04	3.42	18.46
W. Frear, State College, Pa	11.91	6.92	7.62	14.74	3.70	18.44
Clifford Richardson, Washington, D. C	15.80	8.08	6.66	14.69	3.39	18.08
Stillwell & Gladding, New York	8.92	6.93	8.52	15.45	3.21	18.66
C. E. Buck, Wilmington, Del .....	.....	6.87	8.16	15.03	3.26	18.29
W. Robertson, Charleston, S. C	8.55	7.55	8.01	15.56	3.31	18.87
M. A. Scovell, Kentucky experiment station	9.09	8.06	6.72	14.78	3.52	18.30
A. M. Potter, Kentucky experiment station	9.27	8.08	6.52	14.60	3.65	18.25
H. B. Battle, North Carolina experiment station ..	9.75	7.40	7.38	14.84	3.34	18.18
A. F. Shirelok, Wood's Holl, Mass	9.10	7.33	7.89	15.22	2.93	18.15
N. W. Lord, Columbus, Ohio	10.83	7.47	7.61	15.08	3.13	18.21
W. McMurtrie, Champaign, Ill .....	.....	10.04	4.48	14.52	3.58	18.10
A. E. Knorr, Department of Agriculture, Washing- ton	8.25	6.78	7.94	14.72	3.34	18.06
J. M. McCandless, Atlanta, Ga	9.50	9.88	5.65	15.53	2.95	18.48
W. W. Cooke, Burlington, Vt .....	.....	7.34	7.82	15.16	3.08	18.84
H. Froehling, Richmond, Va .....	.....	7.39	7.67	15.06	3.30	18.36
P. E. Chazal, Columbia, S. C	8.95	8.25	7.65	15.90	3.10	19.00
Bradley Fertilizer Company (Benson), Boston .....	.....	7.11	7.95	15.00	3.54	18.60
Bradley Fertilizer Company (Patrick), Boston .....	.....	7.95	7.05	15.00	3.70	18.70

Averages.

	Number of determinations.	Average.	Highest.	Lowest.	Difference.
Sample No. 1:					
Moisture	17	.95	1.37	.78	.61
Phosphoric acid	31	28.07	28.78	27.47	1.31
Sample No. 2:					
Moisture	17	6.70	7.64	6.03	1.61
Phosphoric acid	31	14.31	14.91	13.62	1.29
Sample No. 3:					
Moisture	24	15.40	19.65	12.60	7.05
Soluble phosphoric acid	32	7.11	8.57	6.60	2.57
Reverted phosphoric acid	32	1.31	2.27	.80	1.47
Available phosphoric acid	32	8.42	9.60	7.92	1.68
Insoluble phosphoric acid	32	1.65	2.20	1.30	.90
Total phosphoric acid	32	10.07	11.49	9.63	1.86
Sample No. 4:					
Moisture	24	9.61	11.14	9.03	2.11
Soluble phosphoric acid	32	10.88	11.51	8.67	2.84
Reverted phosphoric acid	32	2.93	5.21	1.21	4.00
Available phosphoric acid	32	13.81	14.29	12.37	1.92
Insoluble phosphoric acid	32	1.95	2.81	1.28	1.53
Total phosphoric acid	32	15.76	16.20	15.18	1.02
Sample No. 5:					
Moisture	24	9.66	15.80	8.09	7.71
Soluble phosphoric acid	32	7.52	10.04	6.00	4.04
Reverted phosphoric acid	32	7.50	9.05	4.48	4.57
Available phosphoric acid	32	15.11	15.90	14.52	1.38
Insoluble phosphoric acid	32	3.40	3.86	2.93	.93
Total phosphoric acid	82	18.51	19.10	18.06	1.18

As further illustrating the differences in the results the following table is presented:

	Percentage of results differing from the average not more than—							
	.10	.25	.50	.75	1.00	1.25	1.50	2.00 and over.
Sample No. 1:								
Moisture	19	61	91	100				
Phosphoric acid	29	52	90	100				
Sample No. 2:								
Moisture	50	94	100					
Phosphoric acid	23	47	70	88	100			
Sample No. 3:								
Moisture			4	17	29	46	58	100
Soluble phosphoric acid	59	78	94	94	94	94	97	100
Reverted phosphoric acid	41	63	97	97	100			
Available phosphoric acid	38	63	97	97	97	100		
Insoluble phosphoric acid	22	69	94	100				
Total	28	59	97	97	97	97	97	100
Sample No. 4:								
Moisture	37	54	87	92	96	96	96	100
Soluble phosphoric acid	31	72	94	97	97	97	97	100
Reverted phosphoric acid	19	44	84	94	94	94	94	100
Available phosphoric acid	22	37	91	97	97	97	100	
Insoluble phosphoric acid	13	59	78	97	100			
Total	9	53	96	100				
Sample No. 5:								
Moisture	12	17	29	63	67	83	87	100
Soluble phosphoric acid	12	28	47	84	84	87	90	100
Reverted phosphoric acid	16	34	53	63	75	88	94	100
Available phosphoric acid	34	59	88	97	100			
Insoluble phosphoric acid	28	66	100					
Total	34	59	94	100				

The committee recommends the continuance of the present general method for the determination of phosphoric acid, subject to such modifications as the association may determine.

Respectfully submitted,

W. J. GASCOYNE,
Chairman.

The report being open for discussion, the president called attention to the dependence of amount of soluble phosphoric acid on the size of filters used during its extraction, and thought it would be well for the committee to recommend a definite size of 9 centimeters.

Professor Frear spoke of differences due to variations in moisture in different laboratories.

Mr. Gascoyne said the variations in moisture was not proportional to the variations in phosphoric acid, and that such differences as 12 and 19 per cent. could not be due to anything but carelessness, the highest determinations of moisture being accompanied by highest percentages of phosphoric acid.

Professor Lupton, on examining the results, said he could see no way to harmonize variations.

The president thought the publication of these results would be most beneficial to the association, and that results another year would be sent in with greater care.

The president then introduced the subject of the use of pumps for extracting soluble phosphoric acid, considering it an advantage where much work was to be done.

Mr. Gascoyne spoke of quick work with molybdate and magnesia solutions, allowing them to stand but five to ten minutes for the yellow precipitate and not more than fifteen for magnesia precipitate.

Mr. Gaines's and Mr. Richardson's experiences confirmed his observations.

On motion of Dr. Wiley, further consideration was postponed till afternoon, and then by unanimous consent he offered certain amendments to the constitution, reported later to the convention, and asked for the appointment of a committee of three under the constitution to consider them.

The president appointed Dr. Wiley, Professor Stubbs, and Professor Voorhees.

On Professor Meyer's motion the convention then adjourned till 2 p. m.

AFTERNOON SESSION, THURSDAY.

The convention was called to order by the president at 2 p. m.

The discussion of the report of the committee on phosphoric acid being in order, it was directed that the method for the coming year provide for the use of Schleicher and Schüll No. 589 filters, 9 centimeters in diameter, in the determination of soluble phosphoric acid, and that the preliminary washing be by decantation from a beaker, using small quantities of water, as described by Messrs. Gascoyne and Voorhees, who considered the use of the pestle only necessary with the very high grade phosphates in New England.

After some argument the use of a pump in determining soluble phosphoric acid was left to the judgment of the analyst.

Dr. Gascoyne then called attention to the method of Isbert & Stutzer for the estimation of phosphoric acid, and gave the following determinations, comparing it with the official method. The method was carefully followed, except that half normal sulphuric acid and caustic soda were used, and cochineal as the indicator.

	Associa- tion method.	Isbert & Stutzer's method.
Acid phosphate.....	16.10	16.08
South Carolina phosphate.....	26.43	26.58
Tankage.....	11.16	11.19
Steamed bone.....	80.15	80.07
Ammoniated superphosphate.....	10.72	10.68
Acid phosphate, total.....	15.77	15.74
Acid phosphate, soluble.....	9.63	9.57
Acid phosphate, insoluble.....	2.26	2.20

He also called attention to the time required for the complete precipitation of the molybdic acid and magnesia precipitates.

The following table is the result of some experiments on this subject. The phosphate was dissolved in the usual manner, filtered, ammonia

added in slight excess, acidified with nitric acid, heated to about 80° or 85° C., the molybdic acid solution added, and the solution well stirred. In the first set of experiments the molybdic precipitate was allowed to stand for five minutes, filtered, magnesia mixture added, and allowed to stand two hours. In the second set, the molybdic precipitate was filtered in ten minutes. In the third set, the molybdic precipitate was allowed to stand one hour, and the magnesia precipitate for fifteen minutes. In the fourth set the magnesia precipitate was allowed to stand thirty minutes. In the fifth set the molybdic acid precipitate stood five minutes, and the magnesia precipitate fifteen to twenty minutes.

[Acid phosphate containing 15.82 by the official method.]

Molybdic precipitate five minutes, magnesia precipitate two hours.....	15.78
Molybdic precipitate ten minutes magnesia precipitate two hours.....	15.80
Molybdic precipitate one hour, magnesia precipitate fifteen minutes.....	15.80
Molybdic precipitate one hour, magnesia precipitate thirty minutes.....	15.82
Molybdic precipitate five minutes, magnesia precipitate fifteen to twenty minutes.....	15.79

	Official method.	Molybdic precipitate, five minutes, magnesia precipitate, 15 to 20 minutes.
Acid phosphate, total.....	16.10	16.07
Acid phosphate, soluble.....	10.22	10.24
Acid phosphate, insoluble.....	2.12	2.08
Ground bone.....	22.14	22.17
Tankage.....	9.93	9.90

The report was then adopted and the committee directed to insert the modifications in the method.

Dr. Wiley then introduced, by permission, Prof. F. W. Clarke, of the U. S. Geological Survey, who addressed the association on the desirability of forming a national chemical society, and suggested the appointment of a committee to represent the association in any steps that might be taken, and this being agreed to, the president appointed Dr. H. W. Wiley, of Washington; Prof. W. C. Stubbs, of Louisiana; and Prof. E. A. von Schweinitz, of North Carolina.

Dr. Wiley then exhibited one of Abbe's large refractometers and read the following paper:

REFRACTIVE INDEX OF BUTTER FAT.

BY H. W. WILEY.

Heretofore very little attention has been given to the refractive index of butter fat in studying the properties of that substance. Having had occasion this year to examine the refractive index of various fats and oils used in the adulteration thereof, I extended the examination to twelve samples of butter fat from butter bought in the open market. The object of the investigation was twofold: First, to determine the mean refractive index; and, second, the rate of variation of the refractive index for rise or fall of temperature. It is, of course, obvious that the refractive index of but-

ter can not be read after it solidifies, and therefore the minimum temperature at which the refractive index can be determined is not much below 30° , although the butter fat may be kept some time even at 25° without solidification. A very warm room where the temperature was reasonably constant was selected in the determination of the refractive index at the lower temperature. For the higher temperature the hot room of a Turkish-bath establishment was used. The temperatures at which the reading was made and the observed index of refraction, the rate of variation for each degree for each sample, and the mean rate of variation for each degree of the twelve samples are given in the following table:

Number.	To.	Index.	Rate for each degree.	Number.	To.	Index.	Rate for each degree.
1.....	32	1.4535	.000169	7.....	32.2	1.4540	.000186
	54.6	1.4497			56.6	1.4495	
2.....	31.9	1.4535	.000165		32.4	1.4540	.000157
	56.2	1.4495		8.....	54.8	1.4505	
3.....	31.8	1.4530	.000194		32.2	1.4538	.000158
	55.0	1.4485		9.....	55.0	1.4500	
4.....	30.8	1.4530	.000146		31.8	1.4530	.000164
	54.8	1.4405		10.....	56.2	1.4490	
5.....	32.3	1.4530	.000153		31.6	1.4540	.000186
	55.8	1.4495		11.....	56.8	1.4493	
6.....	33.2	1.4535	.000203		31.8	1.4528	.000171
	55.4	1.4888		12.....	56.2	1.4485	

The reading of the instrument with distilled water at $18^{\circ} = 1.3305$. Having determined the rate of variation for butter fats, in order to reduce the reading to any standard temperature it is simply necessary to use the mean factor and add or subtract the result of the multiplication as the case may be. For instance, take the case of the first sample. The refractive index at 32° is 1.4535; suppose it is wished to reduce this to a temperature of 25° ; the difference in temperature between 32° and 25° is 7° , the mean rate of variation for each degree is .000171, for 7° it would be .001197. Since the index of refraction would be higher at 25° than at 30° we add this number to the number obtained above. Then $1.4535 + .001197 = 1.4547 =$ index of refraction of that sample at 25° . The index of refraction of butter fat is distinctly lower than that of cotton-seed oil, lard oil, olive oil, and linseed oil. The rate of variation for change of temperature is also less for that of butter fat than the substances mentioned.

On the conclusion of Dr. Wiley's paper a practical demonstration of the working of the lactocrite was given by Mr. A. E. Knorr, after which the convention adjourned until Friday at 10 o'clock.

FRIDAY MORNING.

The convention was called to order at 10 o'clock by the president.

Dr. Farrington called attention to the fact that water was as suitable for washing the yellow molybdate precipitate as ammoniac nitrate.

Isbert and Stützer had observed this, and Dr. Gascoyne said that his experience confirmed it.

On motion, the committee on phosphoric acid was directed to insert this as an alternative in the methods.

Dr. Crampton, in the absence of the chairman, Professor Rising, presented the report of the committee on fermented liquors, as contained in the following letter:

OFFICE OF STATE ANALYST,
Berkeley, July 18, 1888.

DEAR SIR: I hope you will not think that I have intentionally been wanting in respect to the other members of the committee on "fermented liquors" because I have till now failed to communicate with you. Early in the year we began some original work upon artificial colors, etc., and it was my expectation to have had some results that I could have submitted to you for your approval before the close of the year, but our work was interrupted by other analyses, and at the last moment the results were not sufficiently satisfactory to offer to the public. However, I believe we are on the right track, and that we may yet be able to recognize many of these artificial colors in a very short time. I had until a few weeks ago fully expected to have been present at the August meeting of the association. I had planned to have spent a few weeks in your laboratory before the annual meeting, and then and there we could have made up our report. This was my plan, but at the last moment I find myself unable to carry it out, and now am unable to make any suggestion. If the association would grant us another year I would promise to be on hand, and I think I could also promise to spend some time in your laboratory, when we could perfect our report. However, if you can make a report I would not in the least hamper you, but wish you to feel at liberty to do so. I have written Professor Wiley and Mr. Clifford Richardson my views, which are intended as an explanation to the association for the failure on my part to do my duty in the matter.

We have proved beyond all question, as I think, the presence of boracic acid in many unadulterated California wines. In addition to the test with tumeric paper we have obtained the flame-test so decided that there can be no doubt. I have just received a new spectroscope, and I shall hope by its aid to settle this point beyond all question. Our method of work is as follows: 50 cubic centimeters to 100 cubic centimeters of wine are evaporated in a platinum dish, ignited, and burned to ash. Part of this ash is transferred to a platinum spoon; such an one as is used for blow-pipe work answers very well. A few drops of the strongest H_2SO_4 (I have used a 96-98 per cent. acid), then alcohol is added and then lighted and immediately blown out, and relighted and again extinguished. The first flash will show the acid very distinctly if it is present.

The adulterations that we have had to look for have been easily detected. The wine in all cases was taken direct from the wine-maker. It was taken upon its sale to the wine-dealer, who had required a certificate of purity before accepting it. Naturally, only pure wine or wine that was believed to be pure would be offered. The only kind of adulteration believed to have been practiced by wine-makers is, first, the use of antiseptics, salicylic acid, sulphurous acid, and boracic acid, coloring matters, alkalis (K_2CO_3) to neutralize excess of acid, etc. The watering of wine (stretching) belongs to the dealer's art, etc. We have not had occasion to investigate this branch of the subject. We examine for plaster, bases added, antiseptics, artificial colors, copper, lead, zinc salts, alcohol, free acid (volatile and non-volatile), solid residue, ash (soluble and insoluble), alkalinity of the soluble portions, sugar, glucose, glycerine, etc., tannic acid, cream of tartar, etc. Some samples of eastern wine were clearly "manufactured."

I have been obliged to go into the country on account of my family and am now in the midst of the Napa Valley wine region and am making the acquaintance of the wine men here, and hope to gain their confidence so that they will consult me in regard to their troubles, etc. There is a strong sentiment among the wine-makers against the use of any agent that could be called an adulterant, and I find them very anxious to maintain the reputation they already have for purity. The wine-dealer is the man we have to fear; he is ready to do almost anything and to get ahead

of the chemist if he can. The Viticultural Commission has sent a special agent to Paris. They have instructed him to go about and get as many of the practices of wine makers and dealers as possible. I find great difficulty in getting a set of samples of wine-coloring substances. They are only sold in original packages, etc., under various names. I shall hope through our special agent to get a pretty complete set, and then if I can identify them and give them their true scientific names, we will have a surer base to stand upon.

I regret that I can not attend the meeting this year. If the convention will continue the committee I think we can get to work very early the coming year, and present to the next convention a valuable contribution to the subject. May I ask you to present my apology to Professor Fellows. I do not know his address, nor can I get it till I return to Berkeley.

Very truly, yours,

W. B. RISING.

Dr. C. A. CRAMPTON,
Agricultural Department, Washington, D. C.

Dr. Crampton added that he thought it advisable to adopt as provisional methods those which he had collated from foreign sources and published in Part III of Bulletin No. 13 of the Division of Chemistry of the United States Department of Agriculture.

Mr. Richards suggested that the committee examine into the subject of alcohol tables and recommend some standard that might be brought into common use, as the English, French, and American are now all different, and since the recent investigation of Squibb all shown to be more or less incorrect.

The suggestions of the committee were then adopted.

Prof. Myers, on behalf of the committee on potash, then presented their report as follows:

REPORT OF THE COMMITTEE ON POTASH.

The committee on the determination of potash would respectfully submit: That since the last meeting of this association little has appeared in chemical literature relating to the determination of potash, so far as we know, which calls for notice here. The method of Lindo as modified by Gladding appears to give universal satisfaction. The New Jersey Agricultural Experiment Station (Report for 1887, p. 175) has determined the potash in forty-eight mixed fertilizers by this method, with certain slight modifications, and also by the Stohmann method. The greatest difference in the results in any case was .27 per cent.; the average difference .08 per cent. In two-thirds of the determinations the differences were not over .10 per cent., and in only one case was the difference over .15 per cent. Stohmann's method gave on the average slightly higher results than the other. The modified Lindo-Gladding method used at the New Jersey station is as follows:

"The solutions were made as described in the [official method] but previous to the addition of ammonium hydrate 1 cubic centimeter of ammonium oxalate was added; the solution was then filled to the mark, thoroughly mixed and filtered; an aliquot part was transferred to a porcelain dish of approximately 60 cubic centimeters capacity. From this dish the material was not removed until the double salt of potassium-platinic chloride was ready to be brought upon the Gooch filter. After the determination was removed from the bath the precipitate was moistened with water, and then washed with 80 per cent. alcohol till all traces of platinic chloride were removed. It was then washed with the saturated ammonium chloride solution recommended. It was found in this laboratory that better results could be secured by adding

this solution to the precipitate in the porcelain dish, and washing by decantation until all salts other than the potassio-platinic chloride were removed. Since a relatively small amount only of the potassio-platinic chloride is necessary to saturate the ammonium chloride solution, these washings were all rejected, the time saved and the greater accuracy secured compensating for the loss of larger amounts of the solution.

After this washing has been completed, the double salt was transferred to the Gooch filter, washed with pure alcohol, dried and weighed. The salt was then dissolved in hot water, and the final weight of the potassio-platinic chloride secured by difference."

SAMPLES FOR ANALYSIS.

Following the custom adopted by the association, very carefully prepared samples were sent out by the committee with the request that they be analyzed and the results reported to the committee. Twenty-one samples were sent, but reports were received from only nine laboratories or analysts, the most of the others informing the committee that, owing to reorganization and changes taking place due to the influence of the "Hatch bill," they could not find the time to complete the work.

The samples sent out by the committee were numbered from one to five inclusive, and consisted of the following compounds: No. 1, chloride of potassium; No. 2, sulphate of potassium; No. 3, an ammoniated superphosphate mixed with No. 2 in such proportions as to give theoretically 13.50 per cent. of K_2O ; No. 4 was calcined kainite; No. 5, an ammoniated superphosphate containing theoretically 5.2 per cent. of K_2O .

Nos. 1 and 2 proved not to be C. P., though bought for C. P. salts.

Table giving the results of the determination of potash in committee's sample.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
E. H. Jenkins, analyst, Connecticut Experiment Station.					Dr. Lupton, analyst, Alabama Experiment Station.				
.....	.....	.....	¹ 17.86	Lost.	54.27	51.53	13.30	19.68	4.90
.....	.....	.....	¹ 17.80	.....	54.20	51.87	13.47	19.67	4.61
² 53.30	53.78	13.51	² 17.89	.....	54.235	51.70	13.385	19.675	4.755
53.16	53.64	13.51	² 17.84	.....					
53.23	53.81	13.51	17.847	.....					
William Frear, analyst, Pennsylvania Experiment Station. ⁴					Dr. Crampton, analyst, Department of Agriculture, Washington.				
² 53.34	54.11	13.53	19.28	5.33	A.O.A.C.	A.O.A.C.	A.O.A.C.	A.O.A.C.	A.O.A.C.
					53.73	53.48	13.70	17.20	4.96
					53.81	53.68	13.82	17.20	4.99
					53.75	.....	13.90	17.26	.....
					53.60	.....	.....	.....	.....
					53.52	.....	.....	.....	.....
Dr. Caldwell's laboratory, Cornell University.					53.082	53.58	13.806	17.22	4.975
53.60	.....	.....	.....	.....	L.G.	L.G.	L.G.	L.G.	L.G.
53.77	.....	.....	.....	.....	54.11	54.10	13.62	17.32	5.13
53.52	53.64	13.15	17.70	5.21	54.03	54.02	13.72	17.32	5.30
53.70	53.66	13.24	17.78	5.18	.....	53.85	13.78	.....	.....
53.647	53.65	13.195	17.77	5.195	54.085	53.993	13.706	17.32	5.21
Dr. Battlo, analyst, North Carolina Experiment Station.					J. A. Myers, analyst, Mississippi A. and M. College.				
53.44	² 54.09	14.49	19.79	6.00	53.30	.....	13.52	² 17.30	.....
53.44	53.71	14.12	20.26	5.82	.....	.....	13.64	17.24	5.16
53.44	53.90	14.305	20.025	5.01	.....	.....	13.58	17.27	.....

¹ and ² Different chemists.

² Not C. P. Contains Na. Mg. S O₂.

⁴ Averages of results.

⁵ Not C. P.

⁶ Different weighings.

⁷ Not satisfactory to analyst, but not time to repeat.

Table giving the results of the determination of potash in committee's sample—Continued.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Dr. B. V. Herff, analyst, Mississippi A. and M. College.					Dr. B. V. Herff, analyst, Mississippi A. and M. College—Continued.				
A. O. A. C.	A. O. A. C.	A. O. A. C.	A. O. A. C.	A. O. A. C.	L. G.	L. G.	L. G.	L. G.	L. G.
.....	.....	13.74	17.64	5.36	.....	.....	.....	17.32	5.22
.....	.....	13.70	17.74	5.26	.....	.....	.....	17.28	.....
.....	.....	13.72	17.62	5.20	.....	.....	.....	.....	.....
.....	.....	.....	17.92	5.12	53.386	53.433	13.49	17.352	5.82
.....	.....	.....	17.76	.....	.....	.....	.....	.....	.....
.....	.....	.....	17.68	.....	B. W. Kilgore, analyst, Mississippi A. and M. College.				
.....	.....	.....	17.50	.....	.....	.....	.....	.....	.....
.....	.....	.....	17.42	.....	.....	.....	.....	.....	.....
.....	.....	13.72	17.647	5.234	53.70	.....	13.87	17.80	5.96
L. G.	L. G.	L. G.	L. G.	L. G.	.....	.....	13.91	17.08	5.83
53.44	53.56	13.50	17.40	5.10	.....	.....	.....	.....	.....
53.36	53.48	13.48	17.40	5.84	.....	.....	13.89	17.44	5.895
53.36	53.32	.....	17.36	5.56	.....	.....	.....	.....	.....
					No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Average.....					53.404	53.524	13.005	18.078	5.295
Maximum.....					54.27	54.11	14.49	20.26	6.00
Minimum.....					53.16	51.53	13.15	17.08	4.61
Difference.....					1.11	2.58	1.34	3.18	1.39
Number of analyses.....					23	17	24	33	22

* Not satisfactory to analyst, but not time to repeat.

Table giving moistures of committee's samples of potash.

Name of analyst.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Dr. Caldwell.....	0.065	0.00	4.40	1.25	5.80
Dr. Frear, Pennsylvania Experiment Station.....	0.88	0.11	6.29	1.67	7.61
Connecticut Experiment Station.....	0.27	0.21	4.19	1.07	(*)
J. A. Myers†.....	0.8	0.15	4.3	1.30	7.50

* No. 5 broken while in shipment.

† Taken at time of bottling samples.

NOTE.—Other analysts failed to report the moisture.

In giving the results of the analyses the usual custom of giving the averages of all of the results is followed, though the committee does not claim that it represents fairly the work of the chemists of the country. It is hoped, however, that the study of the results of these analyses may lead to more careful work by the various analysts in determining this very difficult element. It is true that among the analyses may be found some results which arise from inexperience, but a perusal of the table shows that some of the very best known analysts in the country differ by more than 0.5 per cent. upon the analysis of the same sample, or as nearly the same sample as it is possible to have mixed and shipped. The most serious difficulty appears to exist with those samples containing sulphate of potassium, *i. e.*, Nos. 2 and 4. In the analyses of these compounds we have some really extraordinary results, a variation of more than 2.5 per cent. occurring between the extremes.

In the cases of at least two of these the attention of the analysts was called to the variation, and the work was at once reviewed. It could not be explained upon t

theory of variation of moisture in the samples, as the determinations of moisture reported by the analysts came almost within the "working error." In reviewing these, different chemists in the same laboratories were placed upon them, and the results arrived at, in the judgment of the chief analysts, justified the report made at first by the chief. Every precaution having been taken to have the samples the same, we are driven to the conclusion that there is some minor variation in the methods practiced in the respective laboratories, or else the scheme now in use is inadequate to overcome the difficulties of the case.

In the cases of the other samples the variations from the mean are not so striking, but are still too considerable to be satisfactory. An analyst finding the minimum per cent. and one finding the maximum per cent., reporting upon any one of these samples would differ by more than 1 per cent., which in a large business transaction based upon such analyses would be quite a serious matter.

The results in the judgment of your committee are highly unsatisfactory. The sources of error in the determination of potash seem not yet to be fully understood by our analytical chemists, and demand the most serious study. This association has been working upon this problem for several years, and appears to have made little or no progress towards removing the difficulties.

The various analysts in any one laboratory appear to agree reasonably well with one another in most cases, but their results frequently do not bear comparison with those obtained elsewhere. In some cases, perhaps, care has not been observed to apply proper corrections for impure PtCl_4 or other sources of error which might be corrected by checking the work of the laboratory by blank determinations with pure KCl .

Your committee would recommend the continuation of the present schemes for determination of potash, with the modification proposed by the New Jersey Experiment Station.

Respectfully submitted.

JOHN A. MYERS, *Chairman*.
WILLIAM FREAR.

The report being open to discussion, Dr. Gascoyne called attention to the recent experiments of Lindo, contained in *Chemical News*, 56, 103, approving the association's method.

Professor Scovell said he had some difficulties, and Mr. Richardson spoke of the presence at times in the case of superphosphates of sulphate of lime in the final double salt.

Mr. Voorhees then described the modification practiced at the New Jersey Agricultural Experiment Station, as given in the eighth annual report, p. 175, and said that they found the Lindo-Gladding method most desirable when a little oxalate of ammonia was used to remove lime, and the evaporation was not carried too low, and referred to the large series of results which he had published in the report referred to.

If the evaporation were carried too far, solids might form which would be insoluble in alcohol, in which case a small quantity of water should first be added, and then the strong alcohol. The greatest error in inexperienced hands lies in this point.

Mr. Chazal said he had also found error in not evaporating low enough.

Mr. Voorhees called attention to the fact that the presence of ammonia in the air of the laboratory produced no effect with the Lindo

method, as the ammonia double salt would afterward be dissolved out by the wash, and then moved the addition to the association method of the use of oxalate with the ammonia and evaporation to dryness with HCl, taking up with water, repeated evaporation, and taking up with alcohol.

This was adopted.

Professor Scovell then presented the report of the committee on nitrogen, as follows :

REPORT OF THE COMMITTEE ON NITROGEN.

Your committee on nitrogen have the honor to present the following report of the work which has been accomplished during the year :

ABSTRACT OF ARTICLES WHICH HAVE APPEARED DURING THE YEAR ON THE DETERMINATION OF NITROGEN IN FERTILIZERS.

[Compiled, by request, by Dr. E. H. Jenkins, Connecticut Agricultural Experiment Station, and A. M. Peter, Kentucky Agricultural Experiment Station.]

The Kjeldahl method.

Lenz (Fres. Zeitschr. Analyt. Chem., 26, p. 590) has tested the effects of omitting oxidation with potassium permanganate after boiling the substance to be analyzed with sulphuric acid. He used a flask of 100 cubic centimeters' capacity, .2-.7 gram of substance, 10 cubic centimeters of oil of vitriol, and .5 gram metallic mercury. The boiling was continued until the substance was clear and colorless. In one series of determinations no permanganate was added; in another it was added as recommended by Kjeldahl. In all cases higher results were obtained when permanganate was used; generally the differences were small, but in some cases amounted to .33 per cent.

Ulsch (Zeitschr. für das gesammte Brauwesen, 1887, p. 3; Fres. Zeitschr., 27, 73) calls attention to the fact that if platinum chloride is added to hasten oxidation when the substance is boiled with oil of vitriol, as recommended by him in a previous paper, an excess must be avoided. Too much platinum chloride retards instead of hastening oxidation, and if the boiling is continued too long, platinum may destroy ammonia by "catalytic action," and so cause loss of nitrogen. He also recommends the use of iron sulphate to destroy mercurio-ammonium compounds formed when mercury is used to hasten oxidation. It has the advantage over potassium sulphide that it can be added to the acid before neutralizing it, thus avoiding danger of losing nitrogen.

Dafert (Landwirtschaft. Versuchs-St., 34, 311; also Fres. Zeitschr. für Analyt. Chem., 27, 222) has studied the chemical reactions involved in the method, and the question how generally applicable the original method of Kjeldahl is, and whether it can be so modified as to make it available for determining nitrogen in all classes of compounds. His conclusions are briefly as follows:

(1) Sulphuric acid withdraws from the nitrogenous organic matter the elements of water and of ammonia, and from them forms ammonia.

(2) The sulphurous acid which is evolved regularly reduces the nitrogenous compounds; but this effect is insignificant compared with that mentioned above.

(3) The addition of organic compounds (sugar, etc.) to nitrogenous matters delays the formation of ammonia, except in cases where it changes a nitrogenous substance, which is volatile or easily decomposed, into one which is less easily attacked by sulphuric acid.

(4) Potassium permanganate, when brought into the hot mixture, destroys the organic compounds still remaining. A part or all of the nitrogen in such compounds forms ammonia. In quantitative work, when the previous digestion with acid has been carried far enough, and the permanganate is added carefully, all the nitrogen is thus converted into ammonia.

(5) His study of the effect of adding metals or metallic oxides leads to the conclusion that the addition of a metal to a substance which is easily oxidized or is easily decomposed by sulphuric acid may cause loss of nitrogen by a too rapid oxidation during the formation of ammonia, and in this way the process is shortened by sacrificing accuracy. Only in special cases, where the substance is very stable, is it safe to use platinum chloride to hasten oxidation, as recommended by Ulsch.

(6) He finds that nitrogen can be accurately determined by the original Kjeldahl method in all amides and ammonium bases, pyridin and chinolin bodies, alkaloids, bitter principles, albuminoids, and allied substances; also most likely in the indol derivatives.

In the following substances nitrogen can not be determined satisfactorily by Kjeldahl's original method.

All nitro-, nitroso-, azo-, diazo-, hydrazo-, and amidoazo- bodies, compounds of nitric and nitrous acids, the hydrazines, and probably cyan- compounds.

For the determination of nitrogen in these classes of compounds probably no general rule can be given, but the peculiarities of each group must be studied as Jodlbauer has studied the special modifications required by nitrates.

E. Waller and H. C. Bowen (Jour. Anal. Chem., 11, 293) give a sketch of the history of the method, and mention modifications which they have adopted, containing nothing essentially new, except that they evaporate off most of the sulphuric acid used in the oxidation of the substance and heat some time after adding the permanganate; an operation which seems hazardous. To the paper is appended a list of the papers which have been published on the Kjeldahl method.

The New Jersey Agricultural Experiment Station (Report N. J. Expt. Sta., 1887, p. 169) has compared, in the case of nineteen fertilizers, the results obtained by the modification of Kjeldahl's method as described by Scovell with those obtained by the absolute method as described in the Report of the Connecticut Experiment Station for 1879. The results showed very satisfactory agreement. The largest difference was .14 per cent.; the average difference, .06 per cent.; in eight cases the absolute method gave on the average .05 per cent. more nitrogen; in eleven cases the modified Kjeldahl method gave on the average .06 per cent. more nitrogen.

E. H. Farrington (Report Conn. Expt. Sta., 1887, p. 126) reports comparative determinations of nitrogen in thirty-four samples of mixed fertilizers containing nitrates by the Jodlbauer-Kjeldahl method and the absolute method as described in the reports of the same station for 1878 and 1879. His conclusions are as follows:

"An inspection of these results shows that in 68 per cent. of the cases the difference between the two methods was not over 0.1 per cent., and in 88 per cent. of the cases not over .15 per cent. The greatest difference was .21 per cent."

"The plus differences are 14 in number; the minus differences, 20. The average of the former is .066; of the latter, .035. It is evident, then, that the two methods are about equally accurate."

Otto Shönherr (Chem. Zeit., 12, 217) applies the azotometer to the Kjeldahl determination. The digestion flasks are graduated by a mark on the neck to a convenient volume (150 cubic centimeters) and after the oxidation has been effected in the usual way the contents of the flask are diluted, neutralized approximately, made up to the mark, and mixed, and an aliquot part (50 cubic centimeters) decomposed in the azotometer with 50 cubic centimeters hypobromite solution. Results accurate.

R. Meldola and E. R. Moritz (Jour. Soc. Chim. Ind., 7, 63) purify sulphuric acid from ammonium sulphate by adding about .05 gram potassium nitrate per 10 cubic centimeters to the acid and heating about two hours.

Other methods.

Houzeau (Pharm. Centr. 28, 627, 628, also Jour. Analyt. Chem. 2, 354) proposes a mixture to be used in determining nitrogen, for the conversion of nitrogen in any combined form into ammonia. Equal weights of sodium acetate and thisulphate are melted in their water of crystallization and allowed to solidify. The mixture is powdered and kept in well-stopped bottles. The combustion is made as follows: In the posterior end of the combustion tube are placed 2 grams of the above mixture and 2 grams of coarsely-pulverized soda-lime, and then a layer of soda-lime a few centimeters long.

The finely-powdered substance to be analyzed (.5 gram if rich in nitrogen, 10-25 if a soil) is well mixed with 10 grams of the salt mixture and 10 grams of soda-lime, and filled into the tube, followed by soda-lime and an asbestos or glass-wool plug. The combustion is made as usual, and the mixture at the rear end of the tube is used at the close of the operation for aspirating. The ammonia is absorbed and titrated in the usual way.

The New Jersey Agricultural Experiment Station (Rep. N. J. Expt. Sta., 1887, p. 169) has determined the nitrogen in 140 samples of complete fertilizers, 22 samples of nitrogenous matter of high grade, and 19 samples of ground bone, both by the soda-lime method and the Kjeldahl method. The latter gave on the average .04 per cent. more nitrogen in complete fertilizers, .05 per cent. more in high-grade nitrogenous matter, and .10 per cent. in bone.

Reference should also be made to an elaborate series of experiments and observations on the soda-lime method made in the laboratory of the Wesleyan University by or under the direction of Prof. W. O. Atwater (Am. Chem. Jour. 9, 311; 10, 111, 113, 197, 262). A complete abstract of these papers is not deemed necessary here. Professor Atwater says, in closing his paper: "The perfection to which Kjeldahl's method has lately been brought, and its accuracy, convenience, and inexpensiveness, have led us to its use in this as in many other laboratories. Our experience leads us to decidedly prefer it to the soda-lime method, though we find it advantageous to use both, making one check the other. But the danger of incomplete ammonification of some classes of compounds, *e. g.*, alkaloids, makes us feel it necessary to control both by the absolute method for all classes of substances except those for which they have been most thoroughly tested."

RESULTS OF WORK DONE.

Last November the chairman of your committee sent out to thirty-one official chemists and others five samples for nitrogen determinations. Twelve have reported results.

Sample No. 1, for the purpose of having the various chemists test the accuracy of their standard solutions, pipettes, burettes, and manipulation.

Samples No. 2 and 5, for comparison of soda-lime method with Kjeldahl.

Samples 1, 3, and 4, to compare the Kjeldahl modified, the Ruffe, and the absolute methods.

In sample No. 4, a chloride was put in for the purpose of seeing whether by the Kjeldahl modified method loss of nitrogen would not follow upon putting sulphuric acid on the substance.

COMPOSITION OF THE SAMPLES.

	Per cent. nitrogen.
No. 1. Potassium nitrate, C. P. (dried at 100 degrees).....	13.85
No. 2. Cotton-seed meal.	
No. 3. Sodium nitrate, C. P. (dried at 100 degrees).....	8.00
Ammonium sulphate, C. P. (dried at 100 degrees).....	6.20
Cotton-seed meal.....	17.00
Acid phosphate.....	68.80
Theoretical per cent. of nitrogen.....	3.93

	Per cent. nitrogen.
No. 4. Sodium nitrate, C. P. (dried at 100 degrees).....	10.00
Cotton-seed meal.....	20.00
Muriate of potash.....	10.00
Acid phosphate.....	60.00
Theoretical per cent. of nitrogen	3.16
No. 5. A mixed tankage of the trade.	
No. 6. Sample of commercial fertilizer sent by Dr. E. H. Jenkins, Connecticut Experiment Station.	
No. 7. Pure sodium nitrate.....	16.47

All the materials, except the tankage, were sifted through a 40-mesh sieve and well mixed before weighing out. The tankage was sifted through a 20-mesh sieve. The constituents, after weighing out, were thoroughly mixed, first with the spatula, on a large sheet of paper, then by running through a drug-mill several times and sifting through the 20-mesh sieve. The mixture was then bottled and sealed as quickly as possible.

A determination by Scovell's method on 2.8 grams acid phosphate gave .02 per cent. of nitrogen. A similar experiment on the muriate of potash gave no nitrogen.

RESULTS OBTAINED.

Soda-lime method.

Analyst.	No. 2.	No. 5.
N. W. Lord.....	.....	2.97
H. W. Wiley.....	7.14	2.85
W. J. Gascoyne.....	7.49	3.01
William Frear.....	6.63	2.83
Wilkinson (Alabama Experiment Station).....	7.70	2.84
Michigan Carbon Works (W. L. Snyder).....	7.47	2.90
National Fertilizer Company (J. H. Kelley).....	7.16	2.89
Average.....	7.26	2.91

Kjeldahl method.

Analyst.	No. 2.	No. 5.
W. J. Gascoyne.....	7.52	2.98
William Frear.....	6.63	2.80
H. W. Wiley.....	7.50	2.91
E. H. Jenkins.....	7.59	3.04
A. M. Peter.....	7.61	3.00
M. A. Scovell.....	7.61	3.03
H. A. Weber.....	7.38	2.97
N. W. Lord.....	7.21	2.94
Average.....	7.38	2.96

Absolute method.

Analyst.	No. 1.	No. 2.	No. 3.	No. 4.	No. 6.
N. W. Lord.....	.....	7.23	4.06	3.52	.....
A. A. Bennett.....	13.86	.....	3.76	.....	.....
E. H. Jenkins.....	.....	.....	.....	3.21	3.19
Winton.....	.....	.....	.....	.....	3.06
C.*.....	.....	.....	.....	.....	3.38
Average.....	13.86	7.23	4.40	3.36	3.14

* Unknown.

Kjeldahl method modified for nitrates.

Analyst.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
W. J. Gascoyne.....	13.80	.....	3.93	3.13	3.03	.....	.....
H. W. Wiley.....	13.73	.....	3.70	3.13	.....	.....	.....
H. A. Weber.....	.....	.....	3.92	3.22	.....	.....	.....
E. H. Jenkins *.....	13.53	.....	3.98	3.09	.....	3.11	.....
William Frear.....	13.86	.....	3.93	2.90	.....	.....	.....
M. A. Scovell.....	13.77	7.45	3.93	3.18	2.98	3.18	16.41
A. M. Peter.....	13.77	7.47	3.96	3.15	3.00	3.17	16.86
G. C. Caldwell.....	13.86	7.82	3.54	2.48	3.19	.....	.....
B.†.....	.....	.....	.....	.....	.....	3.45	.....
C.†.....	.....	.....	.....	.....	.....	3.16	.....
D.†.....	.....	.....	.....	.....	.....	3.16	.....
Average.....	13.76	7.58	3.86	3.03	3.05	3.20	16.39

* Phenol used in place of salicylic acid, and digested one-half hour in the cold before heating.

† Unknown.

Ruffle method.

Analyst.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
H. W. Wiley.....	13.83	7.47	3.86	3.16	2.97
William Frear *.....	12.04	.....	3.48	2.81	.....
W. J. Gascoyne.....	13.68	.....	3.92	3.10	.....
Wilkinson (Alabama Experiment Station).....	13.50	7.42	3.87	2.90	3.05
National Fertilizer Company (J. H. Kelley).....	13.86	7.27	4.00	2.22	2.92
Average.....	13.38	7.38	3.83	2.85	2.98

* Professor Frear reports the following results on Nos. 1, 3, and 4 by using charcoal in the place of sugar: No. 1, 13.78; No. 3, 4.16; No. 4, 3.43.

AVERAGES.

Method.	Sample.	No. of analysts.	Average.	Highest.	Lowest.	Difference.
Soda lime.....	2	6	7.28	7.70	7.14	0.56
	5	7	2.91	3.01	2.83	0.18
Kjeldahl.....	2	8	7.98	7.61	6.63	0.98
	5	8	2.96	3.04	2.80	0.24
Kjeldahl modified for nitrates.	1	7	13.76	13.86	13.55	0.31
	3	8	3.86	3.98	3.54	0.44
	4	8	3.03	3.22	2.48	0.74
Ruffle.....	1	5	13.38	13.86	12.04	1.82
	3	5	3.83	4.00	3.48	0.52
	4	5	2.85	3.16	2.22	0.94

REMARKS.

In the soda-lime method the results on No. 5 are quite satisfactory, the average being about .1 lower than with the Kjeldahl method.

On sample No. 2, however, the results are very unsatisfactory. Even by leaving out one result so far away from the others as to show an error of the chemist, the results vary too much to draw any other conclusion than that, if the soda-lime method is used, much more care must be taken on such samples as cotton-seed meal. In the Kjeldahl method all results agree closely with two exceptions in No. 2, and one exception in No. 5. Leaving out these exceptions, the results of which are so far out of the way as to reflect inaccuracy on the part of the analyst rather than the method, the results are highly satisfactory.

On No. 2 the average is 7.49, the highest 7.61, the lowest 7.38, and the difference between highest and lowest 0.23.

On No. 5, average 3.00, highest 3.04, lowest 2.91, difference 0.13 per cent.

The Kjeldahl shows far better agreeing results than the soda-lime method and gives an average of .23 per cent. higher results on No. 2 and .09 on No. 5.

The Ruffle method shows by the results that it is capable of bringing accurate results, but that it seems of difficult manipulation by many chemists.

On sample No. 1, leaving out one result evidently an error, the average is 13.72, the highest 13.86, the lowest 13.50, difference 0.36.

On sample No. 3, the average is 3.91, highest 4.00, lowest 3.86, difference .14.

On sample No. 4, average 2.85, highest 3.16, lowest 2.81, difference 0.35.

The Kjeldahl method modified for nitrates, although a new method and used by the chemists for the first time as an official method, gives very concordant results.

On sample No. 1 the average is 13.76, and leaving out one low result 13.80, theory 13.85, highest 13.86, lowest 13.73, difference 0.13.

On sample No. 3, average 3.91, highest 3.98, lowest 3.70, difference 0.28, calculated result 3.93.

On sample No. 4, average 3.12, highest 3.22, lowest 3.09, difference 0.13, calculated 3.16.

As compared with the Ruffle method the modified Kjeldahl shows higher results on No. 1 by .05, on No. 3 the average is identical, on No. 4 the average 0.27 per cent. greater.

The absolute method has been used only by two chemists and the results are at so great a variance that no comparison can be made.

RECOMMENDATIONS.

Your committee would recommend the continuance of the five methods adopted last year, viz:

- (1) The absolute method.
- (2) The Kjeldahl method.
- (3) The Kjeldahl method modified for nitrates.
- (4) The Ruffle method.
- (5) The soda-lime method.

But after a careful consideration of the results obtained above, they would recommend:

(1) That the soda-lime method be given more in detail, in the hopes of obtaining more concordant results.

(2) That detail changes be made in the Kjeldahl methods.

(3) That attention be called to the use of zinc-dust, in the Kjeldahl modified method. Prof. H. A. Weber calls attention to the fact that unless the zinc-dust be in an impalpable powder and well mixed into the solution, the nascent hydrogen fails to come in contact with all the nitro-compounds and therefore reduction is incomplete. As an example he gives the following results:

Sample.	No. 3.	No. 4.
Finely pulverized zinc.....	3.46	2.80
Zinc impalpable powder.....	3.92	3.23

Respectfully submitted.

M. A. SCOVELL,
Chairman.
N. T. LUPTON.

Discussion of the report being in order, Messrs. Frear, Gascoyne, and Voorhees stated that they had found trouble with zinc dust, blanks showing some nitrogen.

Dr. Voorhees said that at the New Jersey Station they always made blanks for error, and questioned whether commercial chemists did so.

Professor Scovell said he had found that sulphuric acid often contained nitrogen, but the strictly C. P. from Eimer & Amend was quite free.

Dr. Voorhees then gave an account of the experiments at his station with the Scovell modification of the Kjeldahl method, as published in their last annual report, and described a convenient form of iron gas-pipe condenser. Of the soda-lime method, Dr. Gascoyne said that the necessity for absence of a channel, as shown by Atwater, was an important factor.

Dr. Voorhees pointed to the necessity of fine division of the substance to at least 60 mesh, while coarse samples could be used with the Kjeldahl method.

Professor Scovell called attention to the generally bad results on cotton-seed and blood with soda lime, in the tables given in his report, and a general opinion that a careful understanding of the details of working this method were very necessary, and without this results would easily fall too low.

With the Scovell modification of the Kjeldahl method general satisfaction was expressed by those who had tried it carefully. The report was then adopted.

Professor Stubbs then presented the report of the committee on sugar, as follows:

REPORT OF THE COMMITTEE ON SUGAR.

The increasing interest in sugar-growing in this country is manifested by the large governmental aid recently given to the manufacture of sugar from sorghum and sugarcane. This interest has created a demand for chemical information relative to all sugar matters, from the raw juice to the manufactured articles, and to meet this demand is one of the increasing duties of this association. A Manual of Sugar Analysis, by J. H. Tucker, published by D. Van Nostrand, New York, in 1881, contains all of the approved methods of analyses up to that date, many of which are still used without modifications in the laboratories of the world. Others have been slightly modified, while a few have been discarded as totally without merit.

In all sugars and sugar products, including raw juices, the following determinations are needed for industrial work:

- (1) Total solids.
- (2) Percentage of sucrose.
- (3) Percentage of invert sugars.
- (4) Ash.

In raw juices.—(1) Syrups and molasses: The total solids may be obtained in the following manner:

- (1) By accurately graduated spindles, preferably Baix.
- (2) By taking specific gravity.
- (3) By evaporating to dryness a weighed quantity mixed with ignited sand in a tarred dish.
- (4) A method (Wiley's) of drying and weighing a piece of filter paper, say 12 by 2 inches, saturating with juice or with molasses (easily disseminated over the paper by means of a few drops of alcohol), drying and reweighing.

Of the above methods only the third is absolutely correct. The fourth in our hands gives results slightly low, while second and first are only approximate. However, the first method, when accurately graduated spindles are used, corrections made for temperature are sufficiently approximate for industrial work. A sufficient time should elapse between the pressing of the cane and the reading of the spindle to permit all the air bubbles to escape; one-half hour is time enough.

Sucrose.—For sugars, raw juices, and sirups sucrose is best determined by a simple polariscopic test, with the following precautions:

- (1) Proper sampling of substance.
- (2) Careful weighing of sample.
- (3) Avoid excess of subacetate of lead.
- (4) Dissipate bubbles, which prevent accurate gauging, by a drop or two of ether.
- (5) Perfect filling of polariscope tube.
- (6) Careful reading of polariscope.
- (7) Making all tests in duplicate.
- (8) Testing the accuracy of polariscope daily. Instead of direct weighing of substance the Ventzke's process may be used. Following the above (see Tucker, pages 261 and 262), all ripe sorghum juices, all sugars, and sirups of above grade give accurate results. With immature sorghum juices double polarizations show increased results. (See Table No. 1.)

TABLE No. 1.—*Analyses of varieties of sorghum from experimental plots of sugar experiment station in Louisiana, made July 12 and 13; all immature.*

Number of variety from experimental plots.	Total solids by Bux.	Per cent. sucrose, polarization.		Per cent. glucose.
		Single.	Double.	
1.....	6.8	1.0	1.81	3.40
2.....	7.0	2.0	2.96	1.90
3.....	9.8	4.8	5.78	1.59
4.....	6.5	0.4	2.00	3.29
5.....	10.9	5.4	6.90	1.82
6.....	9.0	2.3	3.95	2.12
7.....	11.7	6.0	7.50	2.13
8.....	10.6	4.8	6.67	2.68
9.....	13.3	6.9	8.81	4.25
10.....	8.5	2.0	4.18	3.40
11.....	11.1	6.2	8.89	1.70
12.....	8.9	0.0	1.58	6.34
14.....	13.2	7.0	7.78	3.71
15.....	13.0	8.4	9.20	2.75
16.....	13.3	8.3	8.95	2.93
17.....	11.8	4.0	5.12	3.40
18.....	11.5	5.2	6.22	3.30
19.....	9.8	2.2	3.22	2.95

With molasses of all kinds, at least from Louisiana cane, simple polarization gives results always too low, especially if during the process of manufacture much sugar has been inverted. Double polarization by Clerget's method of inversion is then usually used for determining the sucrose in these bodies, and when invert sugar is the only optically active body, is approximately accurate. When optically active bodies other than invert sugar are present, recourse must be had to inversion and estimations by Fehling's or Violette's methods. Tuchsmidt has confirmed the accuracy of Clerget's process, and Reichardt and Bellman have perfected it, giving us what is now known to us as Clerget's method.

Creydt, on the other hand, has corrected the constant 144 of Clerget and substituted therefore 142. He further prescribes HCl of 1.1888 specific gravity, equal to 38 per cent. of acid, and washed with this acid the bone charcoal used for filter, dries, and pulverizes it. Herzfeld thinks the exact truth as to this constant is not yet known on account of the difficulties, first, of maintaining the temperature of observa-

tion ; second, the nature of the so-called "pure sugar" used. Landolt recently adds other errors, among others, that 1° Ventzke (white light)=0.34455 circular degrees (sodium light) is too high, and that diverse active substances give numbers sensibly different. He has found with Dr. Rallyan for 1° Ventzke (white light). Sucrose = 0.3465, dextrose = 0.3448, invert sugar = 0.3433 circular degrees. Landolt finds the constant of Clerget to be 142.4, an expression believed to-day to be the most exact. Herzfeld gives a perfected Clerget method which has the following differences: Water of local temperature surrounds the tube, which cools the solution, at once permitting accurate reading of temperature. The use of washed and dried bone-black after Reichart and Bellman, and calculation of results according to the formula of Clerget, modified by Landolt, viz:

$$R = \frac{100S}{142.4 - \frac{1}{T}}$$

The following table of work, carefully done by my assistant, Prof. W. L. Hutchinson, with molasses from different plantations in Louisiana, shows results by double polarization and inversion and estimation with Fehling's solution.

TABLE NO. 2.

Number.	Where from—plantation.	Beaumé.	Specific gravity.	Total solids.	Percent sucrose by double polariscope.	Percent glucose.	Other solids.	Percent sucrose by Fehling.	Total sugar as glucose.
1	Belle Chasseo.....	41.4	1.4039	78.2	89.59	24.82	15.03	39.65	65.06
2	John Crossly & Sons.....	41.8	1.4002	79.0	41.63	22.69	14.44	40.61	65.44
3	Joseph Garr.....	40.6	1.3933	76.6	34.91	29.19	9.05	33.25	63.14
4	Boujere.....	40.7	1.3940	76.7	37.62	24.77	15.32	37.53	61.28
5	Belle Terre.....	41.6	1.4095	78.6	42.57	22.78	14.63	41.30	66.26
6	Woodlawn.....	42.3	1.4185	80.1	33.42	33.75	14.40	32.79	68.22
7	Crescent.....	42.3	1.4185	80.1	36.44	28.42	14.92	37.67	67.08
8	Mary.....	42.3	1.4165	80.1	36.82	26.86	10.72	39.08	67.84
9	Perseverance.....	43.2	1.4287	81.9	40.31	20.00	22.93	43.54	65.84
10	David.....	42.3	1.4165	80.1	37.62	26.92	10.72	36.97	65.84
11	Orange Grove.....	42.4	1.4179	80.3	42.25	24.73	13.05	39.94	68.78
12	Palo Alto.....	42.6	1.4205	80.7	38.14	25.96	16.43	40.28	68.36
13	Hester.....	42.5	1.4192	80.5	34.72	30.17	18.52	33.14	65.06

While the concurrence of results in the main are satisfactory, there are some which could not be made to agree, suggesting strongly either a fault in the method or other optically active bodies than invert sugar, perhaps both; and while for the present we recommend Clerget's method we earnestly request an investigation of Herzfeld's modification of Clerget's method during the coming year by all sugar chemists.

INVERT SUGAR.

The exact estimation of invert sugar in sugar matters has been recently ably investigated and discussed. Heretofore invert sugar has been determined by a simple titration with the cupric tartrate liquor of Fehling, Violette, etc. The formulas for the preparation of these solutions are numerous. They all contain sulphate of copper, rochelle salts, and caustic alkali and present little real difference. Meissl and Herzfeld have described a process based upon the weight of copper reduced from the Fehling solution when accompanied by particular conditions. In spite of its great precision it has found only limited application, especially in France, where its numerous difficulties have prevented its use on an extensive scale. Beggart employs Fehling's solution, which he keeps in bottles (bouchées à l'èmeri) and which are placed in a dark place. To titrate this liquid they dissolve 0.95 gram of pure sugar in a little water with 2 cubic centimeters of hydrochloric acid, and after adding 500 cubic cen-

timeters of water it is gently heated for ten minutes at 70° C. This solution is cooled and saturated with bicarbonate of soda and raised to one liter; .25 cubic centimeters of this liquid will reduce 5 cubic centimeters of Fehling's solution, the end reaction being determined as usual by means of ferrocyanide of potash and acetic acid, using Wiley's tubes.

To preserve a standard solution of invert sugar he prepares a 15 per cent. solution and make strongly alkaline. In this way it will be preserved many months. With this solution he daily tests his Fehling's solution. This constitutes the only merit of this process, a merit which should be observed in every process using the cupric tartrate process.

Patterson's process is based upon another principle. To 100 cubic centimeters of Fehling's solution he adds a quantity of sugar insufficient to precipitate all the copper, and determines excess of copper by a titration with a normal invert sugar solution containing .002 grams per cubic centimeter. Herzfeld rightly condemns the process, since no correct conclusions from the use of the cupric tartrate solution can be drawn without considering the strength of ebullition and influence of crystallizable sugar upon the reducing power of invert sugar.

All the copper liquids so far proposed, although different in composition, have one common property, viz, they all contain a salt of copper, a double tartrate of potash and soda, and caustic or carbonated alkali. They are all reduced not only by invert sugar but also by dextrine and sometimes even by sucrose. After a certain time they undergo alteration, deposit the oxide of copper, especially if exposed to light.

Soldaini's solution does not possess these objectionable qualities, at least so says Degener, who has studied carefully its properties.

This liquid is prepared, according to Degener, in following manner: (1) 40 grams of sulphate of copper is dissolved in water, and, in another vessel, 40 grams of carbonate of soda is also dissolved in water. The two solutions are mixed and the copper precipitated in the state of hydrobasic carbonate according to following equation: $2 \text{CuSO}_4 + 2 \text{Na}_2\text{CO}_3 + \text{H}_2\text{O} = \text{CuCO}_3\text{CuOH}_2\text{O} + \text{CO}_2 + 2 \text{Na}_2\text{SO}_4$. The precipitate is washed with cold water and dried. This precipitate (15 grams) is added to a very concentrated and boiling solution of bicarbonate of potash (about 415 grams) and agitated until the whole is completely, or nearly so, dissolved, water is added to form a volume of 1,400 cubic centimeters, and the whole mass heated for two hours upon a water bath. The insoluble matter is filtered and the filtrate, after cooling, is of a deep blue color and has a density of about 22° 5 Baumé (1.185). The sensibility of this liquid is so great that it gives a decided reaction with .0014 grams of invert sugar. The presence of sucrose in the solution increases still this sensibility. Ammoniacal salts are not hurtful to the reaction, but they do sometimes retain in solution a slight quantity of copper.

It is then indispensable to boil the solution for five minutes at least in order to drive off ammonia. The quantitative test for sugar is made in the following manner: Fifty cubic centimeters of Soldaini's solution is boiled for five minutes upon a water bath, and 15 cubic centimeters of the sugar liquid (containing 100 grams of matter in 100 cubic centimeters of water) added, and boiled again for five minutes. After a rapid cooling the liquid is thrown upon a Swedish filter and washed with water until every trace of a blue color disappears. Then the paper is removed and the precipitate examined, which should be of a clear red color.

Bodenbaender and Schiller (Zeitschrift des Vereins für Rübenzucker-Industrie, 1887, page 138) have determined the following quantitative process with this liquid: One hundred to 150 cubic centimeters of Soldaini's solution is placed in an Erlenmeyer flask and heated for five minutes over a gas jet. A solution containing 10 grams of sugar (clarified with subacetate of lead if necessary) is added, and heated again for five minutes, always over a direct flame. This precipitates all the copper, to which is added 100 cubic centimeters of distilled water, in order to cool the mass very quickly. The trouble liquid is filtered (preferably through a Soxhlet or Herzfeld filter) and washed

with distilled water. This oxide of copper is reduced in a current of hydrogen, and the copper is weighed in a metallic form, and this weight multiplied by .3546 gives the weight of invert sugar. By this method .01 per cent. of invert sugar can be accurately determined.

Sidersky has recently offered a new volumetric method based upon the use of Sol-dain's solution. With sugars the same method as is now in use with Fehling's solution can easily be followed, watching the disappearance of the blue color, and testing the end with ferrocyanide of potash and acetic acid. This process offers no serious objections common to Fehling's solution, but is inapplicable to colored sugar solutions, such as molasses, etc. For the last the following is recommended: twenty-five grams of molasses is dissolved in 100 cubic centimeters of water and subacetate of lead added in sufficient quantities to precipitate the impurities, and the volume raised to 200 cubic centimeters and filtered. To 100 cubic centimeters of the filtrate are added 25 cubic centimeters of concentrated solution of carbonate of soda, agitated and filtered again. One hundred cubic centimeters of the second filtrate with excess of lead removed is taken for analysis. On the other hand, 100 cubic centimeters of Sol-dain's solution is added to a flask of Bohemian glass and heated five minutes over an open flame. The sugar solution is now added a little by little, and the heating continued for five minutes. Finally, the heat is withdrawn and cooled by turning in 100 cubic centimeters of cold water, and filtered through a Swedish filter, washed with hot water, letting each washing run off before another addition. Three or four washings will generally remove completely the alkaline reaction. The precipitate is then washed through a hole in the filter into a flask, removing the last trace of copper. Twenty-five cubic centimeters of normal sulphuric acid is added, with two or three crystals of chlorate of potash, and the whole gently heated to dissolve completely the oxide of copper, which is transformed into copper sulphate, according to equation, $3\text{Cu}_2\text{O} + 6\text{H}_2\text{SO}_4 + \text{KClO}_3 = 6\text{CuSO}_4 + 6\text{H}_2\text{O} + \text{KCl}$. The excess of sulphuric acid is determined by a standard ammonia solution (semi-normal) of which the best indicator is the sulphate of copper itself. When the deep blue color gives place to a greenish tinge the titration is completed. The method of titration is performed as follows: Having cooled the contents of the flask, a quantity of ammonia equivalent to 25 cubic centimeters of normal sulphuric acid added. From a burette graduated into one-tenth cubic centimeters standard sulphuric acid is dropped in drop by drop, agitating after each addition. The blue color disappears with each addition to reappear after shaking. When the last trace of ammonia is saturated the titration is complete, which is known by a very feeble greenish tinge. The number of cubic centimeters is read from the burette, which is equivalent to the copper precipitated. The equivalent of copper is 31.7, and the normal acid equivalent is .0317 of copper. Multiplying the copper found by 3546 we have the invert sugar. A blank titration is needed to accurately determine the slight excess which gives the pale green tinge. This process is to be highly recommended if experiments show it to be as accurate in our hands as it has in France.

(4) *Ash*.—For the determination of ash, Scheibler's process of ignition with H_2SO_4 and deducting one-tenth is recommended. For details, see Tucker's Manual, page 226.

Your committee, in conclusion, recommends that for technical work the following is admissible:

(1) Taking the total solids with an accurately graduating Brix spindle and correcting for temperature.

(2) A polariscopic test for raw juices, low sirups and sugars, using the precautions mentioned in this report.

(3) For heavy sirups, molasses, and tank bottoms, double polarization with Clerget's tables.

(4) For invert sugar, use Fehling's or Violett's solutions, preferably the last, using as an end reaction ferrocyanide of potash and acetic acid; best accomplished by use of Wiley's tubes.

(5) Ignition with sulphuric acid at a low red heat and deducting one-tenth for ash. For laboratory work the above may be substituted by some of the more accurate methods given above.

Respectfully submitted.

W. C. STUBBS,
Chairman.

REMARKS ON PROFESSOR STUBBS'S REPORT.

By H. W. WILEY.

MR. PRESIDENT. In connection with the report of Professor Stubbs on sugar analysis, which has just been presented to the association, I beg leave to call the attention of the members to a standard polariscope which I have had constructed by Schmidt & Haensch in Berlin. This instrument is the double compensating apparatus manufactured by that firm, which has already gained great favor among chemists. The apparatus which I show you was specially constructed for the use of this Department, and is capable of receiving an observation tube 600 millimeters in length.

By means of the double compensating apparatus any error which may be due to an inaccuracy in the quartz wedge is reduced to a minimum. The apparatus has the advantage of using ordinary lamp-light, which is of great importance when outside-station work is to be considered, where the difficulty of securing a monochromatic flame is great. This instrument has lately been examined by Professor Andrews, the expert employed by the United States Treasury to investigate the methods of sugar analysis employed in the United States custom-houses. He proved it to be as nearly exact as any instrument can be made. It is not necessary to mention that for general purposes of research a rotation instrument like the large model Laurent is preferable to any form of compensating apparatus; but in sugar work, where an arbitrary scale is used, I think an instrument of this kind would be found superior to anything now in use.

The report of the committee on sugar was then adopted. The committee on amendments to the constitution then submitted the following:

Amendment to article 4.

Article 4 to read as follows:

There shall be appointed by the president at the regular annual meeting a reporter for each of the subjects to be considered by the association.

It shall be the duty of these reporters to test methods, to prepare and distribute samples and standard re-agents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof and recommendations of methods to be followed.

Addition to article 2.

All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members and to all privileges of membership save the right to hold office and to vote.

Approved.

H. W. WILEY.
WM. C. STUBBS.
E. B. VOORHEES.

The report of the committee was then adopted, and the amendments made part of the constitution.

The committee on elections then reported that "hereafter all officers be elected by ballot."

In accordance therewith the convention proceeded to an election, with the following result:

President: Prof. John A. Myers, of West Virginia.

Vice-president: Prof. M. A. Scovell, of Kentucky.

Secretary: Mr. Clifford Richardson, of Washington.

Executive committee: Dr. H. W. Wiley, of Washington; Dr. William Frear, of Pennsylvania.

It was then agreed that the committee on branding bags, labels, etc., be continued, with Professor White substituted for Professor McMurtrie.

Professor Myers then moved, and it was adopted:

That the hearty thanks of the convention be returned to Hon. Norman J. Colman, Commissioner of Agriculture, for his courtesies and cordial co-operation in the work of the association.

The convention then, on motion of Professor Scovell, adjourned *sine die*.

OFFICIAL METHODS OF ANALYSIS OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS FOR 1887-'88.

METHODS FOR DETERMINING PHOSPHORIC ACID AND MOISTURE.

(1) *Preparation of sample.*—The sample should be well intermixed and properly prepared, so that separate portions shall accurately represent the substance under examination, without loss or gain of moisture.

(2) *Determination of moisture.*—(a) In potash salts, nitrate of soda, and sulphate of ammonia heat 1 to 5 grams at 130° C. till the weight is constant, and reckon water from the loss. (b) In all other fertilizers heat 2 grams, or if the sample is too coarse to secure uniform lots of 2 grams each, 5 grams, for five hours, at 100° in a steam bath.

(3) *Water-soluble phosphoric acid.*—Weigh out 2 grams in a small beaker, wash by decantation four or five times with not more than from 10 to 15 cubic centimeters of water, then rub it up in the beaker with a rubber-tipped pestle to a homogeneous paste, and then wash four or five times by decantation with from 10 to 15 cubic centimeters of water. Transfer the residue to a 9 cubic centimeter, No. 589 Schleicher and Schüll filter, and wash with water until the filtrate measures not less than 250 cubic centimeters. Mix the washings. Take an aliquot (corresponding to $\frac{1}{2}$ gram) and determine phosphoric acid, as under total phosphoric acid.

(4) *Citrate-insoluble phosphoric acid.*—Wash the residue of the treatment with water into a 200 cubic centimeter flask with 100 cubic centimeters of strictly neutral ammonium citrate solution of 1.09 density, prepared as hereafter directed. Cork the flask securely and place it in a water bath, the water of which stands at 65° C. (The water bath should be of such a size that the introduction of the cold flask or flasks shall not cause a reduction of the temperature of the bath of more than 2° C.) Raising the temperature as rapidly as practicable to 65° C., which is subsequently maintained, digest with frequent shakings for thirty minutes from the instant of insertion, filter the warm solution quickly (best with filter-pump), and wash with water of ordinary temperature. Transfer the filter and its contents to a capsule, ignite until the organic matter is destroyed, treat with 10 to 15 cubic centimeters

of concentrated hydrochloric or nitric acid, digest over a low flame until the phosphate is dissolved, dilute to 200 cubic centimeters, mix, pass through a dry filter, take an aliquot and determine phosphoric acid as under total.

In case a determination of citrate-insoluble phosphoric acid is required in non-acidulated goods, it is to be made by treating 2 grams of the phosphatic material, without previous washing with water, precisely in the way above described, except that in case the substance contains much animal matter (bone, fish, etc.), the residue insoluble in ammonium citrate is to be treated by one of the processes described below.

(5) *Total phosphoric acid*.—Weigh 2 grams and treat by one of the following methods: (1) Evaporation with 5 cubic centimeters magnesium nitrate, ignition, and solution in acid. (2) Solution in 30 cubic centimeters concentrated nitric acid with a small quantity of hydrochloric acid. (3) Add 30 cubic centimeters concentrated hydrochloric acid, heat, and add cautiously and in small quantities at a time about 0.5 gram of finely pulverized potassium chlorate.

Boil gently until all phosphates are dissolved and all organic matter destroyed; dilute to 200 cubic centimeters; mix and pass through a dry filter; take 50 cubic centimeters of filtrate; neutralize with ammonia (in case hydrochloric acid has been used as a solvent add about 15 grams dry ammonium nitrate or its equivalent). To the hot solutions for every decigram of P_2O_5 that is present, add 50 cubic centimeters of molybdic solution. Digest at about $65^\circ C$. for one hour, filter, and wash with water or ammonium nitrate solution. (Test the filtrate by renewed digestion and addition of more molybdic solution.) Dissolve the precipitate on the filter with ammonia and hot water and wash into a beaker to a bulk of not more than 100 cubic centimeters. Nearly neutralize with hydrochloric acid, cool, and add magnesia mixture from a burette; add slowly (one drop per second), stirring vigorously. After fifteen minutes add 30 cubic centimeters of ammonia solution of density 0.95. Let stand several hours (two hours is usually enough). Filter, wash with dilute ammonia, ignite intensely for ten minutes, and weigh.

(6) *Citrate-soluble phosphoric acid*. The sum of the water-soluble and citric insoluble subtracted from the total gives the citrate-soluble.

PREPARATION OF REAGENTS.

(1) *To prepare ammonium citrate solution*.—Mix 370 grams of commercial citric acid with 1,500 cubic centimeters of water; nearly neutralize with crushed commercial carbonate of ammonia; heat to expel the carbonic acid; cool; add ammonia until exactly neutral (testing by saturated alcoholic solution of coralline) and bring to volume of two liters. Test the gravity, which should be 1.09 at $20^\circ C$., before using.

(2) *To prepare molybdic solution*.—Dissolve 100 grams of molybdic acid in 400 grams or 417 cubic centimeters of ammonia of specific grav-

ity 0.96, and pour the solution thus obtained into 1,500 grams or 1,250 cubic centimeters of nitric acid of specific gravity 1.20. Keep the mixture in a warm place for several days, or until a portion heated to 40° C. deposits no yellow precipitate of ammonium phospho-molybdate. Decant the solution from any sediment, and preserve in glass-stoppered vessels.

(3) *To prepare ammonium nitrate solution.*—Dissolve 200 grams of commercial ammonium nitrate in water and bring to a volume of two liters.

(4) *To prepare magnesia mixture.*—Dissolve 22 grams of recently ignited calcined magnesia in dilute hydrochloric acid, avoiding excess of the latter. Add a little calcined magnesia in excess, and boil a few minutes to precipitate iron, alumina, and phosphoric acid; filter, add 280 grams of ammonium chloride, 700 cubic centimeters of ammonia of specific gravity 0.96, and water enough to make the volume of two liters. Instead of the solution of 22 grams of calcined magnesia 110 grams of crystallized magnesium chloride ($\text{MgCl}_2, 6\text{H}_2\text{O}$) may be used.

(5) *Dilute ammonia for washing.*—One volume ammonia of specific gravity 0.96 mixed with three volumes of water, or usually one volume of concentrated ammonia with six volumes of water.

(6) *Nitrate of magnesia.*—Dissolve 320 grams of calcined magnesia in nitric acid, avoiding an excess of the latter; then add a little calcined magnesia in excess; boil; filter from excess of magnesia, ferric oxide, etc., and bring to volume of two liters.

METHODS OF DETERMINING POTASH.

METHOD OF LINDO AS MODIFIED BY GLADDING.

(1) *Superphosphates.*—Boil 10 grams of the fertilizer with 300 cubic centimeters of water for ten minutes. Cool the solution; add a little oxalate of ammonia and then ammonia in slight excess, thus precipitating all phosphate and sulphate of lime, oxide of iron, and alumina, etc.; make up to 500 cubic centimeters, mix thoroughly and filter through a dry filter; take 50 cubic centimeters corresponding to 1 gram, evaporate nearly to dryness, add 1 cubic centimeter of dilute H_2SO_4 (1 to 1), and evaporate to dryness and ignite to whiteness. As all the potash is in form of sulphate, no loss need be apprehended by volatilization of potash, and a full red heat must be used until the residue is perfectly white. This residue is dissolved in hot water plus a few drops of HCl ; 5 cubic centimeters of a solution of pure NaCl (containing 20 grams NaCl to the liter) and an excess of platinum solution (4 cubic centimeters) are now added. This solution is then evaporated to dryness in a small dish, the residue taken up with a little water, sufficient to dissolve it, and strong alcohol added. The precipitate is washed thoroughly with alcohol by decantation and on filter as usual. The wash-

ing should be continued even after the filtrate is colorless. Ten cubic centimeters of the NH_4Cl solution prepared as directed are now run through the filter, or the washing may be performed in the dish. These 10 cubic centimeters will contain the bulk of the impurities, and are thrown away. Fresh portions of 10 cubic centimeters NH_4Cl are now run through the filter several times (five or six). The filter is then washed thoroughly with pure alcohol, dried, and weighed as usual. The platinum solution used contains 1 gram metallic platinum in every 10 cubic centimeters.

(2) *Muriates of potash*.—In the analysis of these salts an aliquot portion, containing .500 gram, is evaporated with 10 cubic centimeters platinum solution plus a few drops of HCl , and washed as before.

(3) *Sulphate of potash, kainite, etc.*—In the analysis of these salts an aliquot portion containing .500 gram is taken, .250 gram of NaCl added, plus a few drops of HCl , and the whole evaporated with 15 cubic centimeters platinum solution. In this case special care must be taken, in the washing with alcohol, to remove all the double chloride of platinum and sodium. The washing should be continued for some time after the filtrate is colorless. Twenty-five cubic centimeters of the NH_4Cl solution are employed, instead of 10 cubic centimeters, and the 25 cubic centimeters poured through at least six times to remove all sulphates and chlorides. Wash finally with alcohol, dry, and weigh as usual.

To prepare the washing solution of NH_4Cl , place in a bottle 500 cubic centimeters H_2O , 100 grams of NH_4Cl ; shake till dissolved. Now pulverize 5 or 10 grams of K_2PtCl_6 , put in the bottle, and shake at intervals for six or eight hours; let settle over night; then filter off liquid into a second bottle. The first bottle is then ready for a preparation of a fresh supply when needed.

ALTERNATE METHOD.

In case the potash is contained in organic compounds, like tobacco stems, cotton-seed hulls, etc., it is to be saturated with strong sulphuric acid and ignited in a muffle to destroy organic matter. Pulverize the fertilizer (200 or 300 grams) in a mortar; take 10 grams, boil for ten minutes with 200 cubic centimeters water, and after cooling, and without filtering, make up to 1,000 cubic centimeters, and filter through a dry paper. If the sample have 10 to 15 per cent. K_2O (kainite), take 50 cubic centimeters of the filtrate; if from 2 to 3 per cent. K_2O (ordinary potash fertilizers), take 100 cubic centimeters of the filtrate. In each case make the volume up to 150 cubic centimeters, heat to 100° , and add, drop by drop, with constant stirring, slight excess of barium chloride; without filtering, in the same manner, add barium hydrate in slight excess. Heat, filter, and wash until precipitate is free of chlorides. Add to filtrate 1 cubic centimeter strong ammonium hydrate, and then a saturated solution of ammonium carbonate until excess of

barium is precipitated. Heat. Add now, in fine powder, 0.5 gram pure oxalic acid or 0.75 gram ammonium oxalate. Filter, wash free of chlorides, evaporate filtrate to dryness in a platinum dish, and, holding dish with crucible tongs, ignite carefully over the free flame below red heat until all volatile matter is driven off.

The residue is now digested with hot water, filtered through a small filter, and washed with successive small portions of water until the filtrate amounts to 30 cubic centimeters or more. To this filtrate, after adding two drops of strong hydrochloric acid, is added, in a porcelain dish, 5 to 10 cubic centimeters of a solution of 10 grams of platinum chloride in 100 cubic centimeters of water. The mixture is now evaporated on the water-bath to a thick sirup, or further, as above treated with strong alcohol, washed by decantation, collected in a Gooch crucible or other form of filter, washed with strong alcohol, afterwards with 5 cubic centimeters ether, dried for thirty minutes at 100°C ., and weighed.

It is desirable, if there is an appearance of foreign matter in the double salt, that it should be washed, according to the previous method, with 10 cubic centimeters of the half-concentrated solution of NH_4Cl , which has been saturated by shaking with K_2PtCl_6 , as recommended by Gladding.

The use of the factor 0.3056 for converting K_2PtCl_6 to KCl and 0.19308 for converting to K_2O are continued.

METHODS FOR THE DETERMINATION OF NITROGEN.

THE ABSOLUTE OR CUPRIC OXIDE METHOD.

(Applicable to all nitrogen determinations.)

The apparatus and re-agents needed are as follows:

APPARATUS.

Combustion tube of best hard Bohemian glass, about 26 inches long and one-half inch internal diameter.

Azotometer of at least 100 cubic centimeters capacity, accurately calibrated.

Sprengel mercury air pump.

Small paper scoop, easily made from stiff writing-paper.

RE-AGENTS.

Cupric oxide (coarse).—Wire form; to be ignited and cooled before using.

Fine cupric oxide.—Prepared by pounding ordinary cupric oxide in mortar.

Metallic copper.—Granulated copper or fine copper gauze reduced and cooled in stream of hydrogen.

Sodium bicarbonate.—Free from organic matter.

Caustic potash solution.—Dissolve commercial stick potash in less than its weight of water so that crystals are deposited on cooling. When absorption of carbonic acid ceases to be prompt solution must be discarded.

LOADING TUBE.

Of ordinary commercial fertilizers take 1 to 2 grams for analysis. In the case of highly nitrogenous substances the amount to be taken must be regulated by the amount of nitrogen estimated to be present. Fill tube as follows: (1) About 2 inches of coarse cupric oxide. (2) Place on the small paper scoop enough of the fine cupric oxide to fill, after having been mixed with the substance to be analyzed, about 4 inches of the tube; pour on this the substance, rinsing watch glass with a little of the fine oxide, and mix thoroughly with spatula; pour into tube, rinsing the scoop with a little fine oxide. (3) About 12 inches of coarse cupric oxide. (4) About 3 inches of metallic copper. (5) About 2½ inches of coarse cupric oxide (anterior layer). (6) Small plug of asbestos. (7) Eight-tenths to 1 gram of sodium bicarbonate. (8) Large, loose plug of asbestos; place tube in furnace, leaving about 1 inch of it projecting; connect with pump by rubber stopper smeared with glycerine, taking care to make connection perfectly tight.

OPERATION.

Exhaust air from tube by means of pump. When a vacuum has been obtained allow flow of mercury to continue, light gas under that part of tube containing metallic copper, anterior layer of cupric oxide (see 5th above) and bicarbonate of soda. As soon as vacuum is destroyed and apparatus filled with carbonic acid gas, shut off the flow of mercury and at once introduce the delivery tube of the pump into the receiving arm of the azotometer, and just below the surface of the mercury seal of the azotometer, so that the escaping bubbles will pass into the air and not into the azotometer, thus avoiding the useless saturation of the caustic potash solution.

When the flow of carbonic acid has very nearly or completely ceased, pass the delivery tube down into the receiving arm, so that the bubbles will escape into the azotometer. Light the jets under the 12-inch layer of oxide, heat gently for a few moments to drive out any moisture that may be present, and bring to red heat. Heat gradually mixture of substance and oxide, lighting one jet at a time. Avoid too rapid evolution of bubbles, which should be allowed to escape at rate of about one per second or a little faster.

When the jets under mixture have all been turned on, light jets under layer of oxide at end of tube. When evolution of gas has ceased turn out all the lights except those under the metallic copper and anterior layer of oxide, and allow to cool for a few moments. Exhaust with pump and remove azotometer before flow of mercury is stopped. Break con-

nection of tube with pump, stop flow of mercury, and extinguish lights. Allow azotometer to stand for at least an hour or cool with stream of water until permanent volume and temperature are reached.

Adjust accurately the level of the KOH solution in bulb to that in azotometer, note volume of gas, temperature, and height of barometer; make calculations as usual. The labor of calculation may be much diminished by the use of the tables prepared by Messrs. Battle and Dancy, of the North Carolina Experiment Station (Raleigh, N. C.).

The above details are, with some modifications, those given in the report of the Connecticut Station for 1879 (p. 124), which may be consulted for details of apparatus, should such details be desired.

THE KJELDAHL METHOD.

(Not applicable in presence of nitrates.)

APPARATUS AND REAGENTS.

(1) Hydrochloric acid, whose absolute strength has been determined (a) by precipitating with silver nitrate and weighing the silver chloride, (b) by sodium carbonate, as described in Fresenius's Quantitative Analysis, second American edition, page 680, and (c) by determining the amount neutralized by the distillate from a weighed quantity of pure ammonium chloride boiled with an excess of sodium hydrate. Half normal acid, *i. e.*, containing 18.25 grams hydrochloric acid to the liter, is recommended.

(2) Standard ammonia whose strength, relative to the acid, has been accurately determined. One-tenth normal ammonia, *i. e.*, containing 1.7 grams ammonia to the liter, is recommended for accurate work.

(3) "C. P." sulphuric acid, specific gravity 1.83, free from nitrates and also from ammonium sulphate, which is sometimes added in the process of manufacture to destroy oxides of nitrogen. Eimer & Amend's "Strictly C. P." is good.

(4) Mercuric oxide, HgO , prepared in the wet way. That prepared from mercury nitrate can not safely be used.

(5) Potassium permanganate tolerably finely pulverized.

(6) Granulated zinc.

(7) A solution of 40 grams of commercial potassium sulphide in one liter of water.

(8) A saturated solution of sodium hydrate free from nitrates, which are sometimes added in the process of manufacture to destroy organic matter and improve the color of the product. That of the Greenbank Alkali Company is of good quality.

(9) Solution of cochineal prepared according to Fresenius's Quantitative Analysis, second American edition, page 679.

(10) Kjeldahl digestion flasks of hard, moderately thick, well annealed glass. These flasks are about 9 inches long, with a round, pear-shaped bottom, having a maximum diameter of $2\frac{1}{2}$ inches, and tapering

out gradually in a long neck, which is three-fourths of an inch in diameter at the narrowest part, and flared a little at the edge. The total capacity is 225 to 250 cubic centimeters.

(11) Distillation flasks of ordinary shape, 550 cubic centimeters capacity, and fitted with a rubber stopper and a bulb tube above to prevent the possibility of sodium hydrate being carried over mechanically during distillation. The bulbs are about $1\frac{1}{2}$ inches in diameter, the tubes being the same diameter as the condenser and cut off obliquely at the lower end. This is adjusted to the tube of the condenser by a rubber tube.

(12) *A condenser*.—Several forms have been described, no one of which is equally convenient for all laboratories. The essential thing is that the tube which carries the steam to be condensed shall be of block-tin. The upper ends of the tin tubes should be bent so that the glass connections may have a slope toward the distilling flasks. All kinds of glass are decomposed by steam and ammonia vapor, and will give up alkali enough to impair accuracy. (See Kreussler and Henzold, Ber. Berichte, XVII, 34.) The condenser in use in the laboratory of the Connecticut Experiment Station, devised by Professor Johnson, consists of a copper tank, supported by a wooden frame, so that its bottom is 11 inches above the work-bench on which it stands. This tank is 16 inches high, 32 inches long, and 3 inches wide from front to back, widening above to 6 inches. It is provided with a water-supply tube, which goes to the bottom, and a larger overflow pipe above. The block-tin condensing tubes, whose external diameter is three-eighths of an inch, seven in number, enter the tank through holes in the front side of it near the top, above the level of the overflow, and pass down perpendicularly through the tank and out through rubber stoppers tightly fitted into holes in the bottom. They project about $1\frac{1}{2}$ inches below the bottom of the tank, and are connected by short rubber tubes with glass bulb tubes of the usual shape, which dip into precipitating beakers or Erlenmeyer flasks of about 300 cubic centimeters capacity. The titration can be made directly in them. The distillation flasks are supported on a sheet-iron shelf, attached to the wooden frame that supports the tanks in front of the latter. Where each flask is to stand a circular hole is cut, with three projecting lips, which support the wire gauze or asbestos under the flask, and three other lips, which hold the flask in place and prevent its moving laterally out of place while distillation is going on. Below this sheet-iron shelf is a metal tube carrying seven Bunsen burners, each with a stop-cock like those of a gas-combustion furnace. These burners are of a larger diameter at the top, which prevents smoking when covered with fine gauze to prevent the flame from striking back.

(13) The stand for holding the digestion flasks consists of a pan of sheet-iron 29 inches long by 8 inches wide, on the front of which is fastened a shelf of sheet-iron as long as the pan, 5 inches wide and 4 inches

high. In this are cut six holes $1\frac{1}{8}$ inches in diameter. At the back of the pan is a stout wire running lengthwise of the stand, 8 inches high, with a bend or depression opposite each hole in the shelf. The digestion flask rests with its lower part over a hole in the shelf and its neck in one of the depressions in the wire frame, which holds it securely in position. Heat is supplied by low Bunsen burners below the shelf. With a little care the naked flame can be applied directly to the flask without danger.

THE DETERMINATION.

(1) *The digestion.*—Seven-tenths to 2.8 grams of the substance to be analyzed, according to its proportion of nitrogen, is brought into a digestion flask with approximately .7 gram of mercuric oxide and 20 cubic centimeters of sulphuric acid. The flask is placed on the frame above described in an inclined position, and heated below the boiling point of the acid for from 5 to 15 minutes, or until frothing has ceased. If the mixture froths badly, a small piece of paraffine may be added to prevent it. The heat is then raised until the acid boils briskly. No further attention is required till the contents of the flask have become a clear liquid, which is colorless, or at least has only a very pale straw color. The flask is then removed from the frame, held upright, and, while still hot, potassium permanganate is dropped in carefully and in small quantity at a time till, after shaking, the liquid remains of a green or purple color.

(2) *The distillation.*—After cooling, the contents of the flask are transferred to the distilling flask with about 200 cubic centimeters of water, and to this a few pieces of granulated zinc and 25 cubic centimeters of potassium sulphide solution are added, shaking the flask to mix its contents. Next add 50 cubic centimeters of the soda solution, or sufficient to make the reaction strongly alkaline, pouring it down the side of the flask so that it does not mix at once with the acid solution. Connect the flask with the condenser, mix the contents by shaking, and distill until all ammonia has passed over into the standard acid. The first 150 cubic centimeters of the distillate will generally contain all of the ammonia. This operation usually requires from forty minutes to one hour and a half. The distillate is then titrated with standard ammonia.

The use of mercuric oxide in this operation greatly shortens the time necessary for digestion, which is rarely over an hour and a half in cases of substances most difficult to oxidize, and is more commonly less than an hour. In most cases the use of potassium permanganate is quite unnecessary, but it is believed that in exceptional cases it is required for complete oxidation, and in view of the uncertainty it is always used. Potassium sulphide removes all mercury from solution, and so prevents the formation of mercurio-ammonium compounds which are not completely decomposed by soda solution. The addition of zinc gives rise to an evolution of hydrogen and prevents violent bumping. Previous

to use the reagents should be tested by a blank experiment with sugar, which will partially reduce any nitrates that are present which might otherwise escape notice.

KJELDAHL METHOD MODIFIED TO INCLUDE THE NITROGEN OF NITRATES.*

(Applicable to all fertilizers containing nitrates.)

Besides the reagents and apparatus given under the Kjeldahl method, there will be needed—

- (1) Zinc dust. This should be an impalpable powder; granulated zinc or zinc filings will not answer.
- (2) Commercial salicylic acid.

THE DETERMINATION.

Bring from .7 to 1.4 grams of the substance to be analyzed into a Kjeldahl digesting flask, add to this 30 cubic centimeters of sulphuric acid containing 2 grams of salicylic acid, and shake thoroughly; then add *gradually* 3 grams of zinc dust, shaking the contents of the flask at the same time. Finally place the flask on the stand for holding the digestion flasks, where it is heated over a low flame until all danger from frothing has passed. The heat is then raised until the acid boils briskly, and the boiling continued until white fumes no longer pour out of the flask. This requires about five or ten minutes. Add now approximately .7 gram mercuric oxide, and continue the boiling until the liquid in the flask is colorless, or nearly so. (In case the contents of the flask are likely to become solid before this point is reached, add 10 cubic centimeters more of sulphuric acid.) Complete the oxidation with a little permanganate of potash in the usual way, and proceed with the distillation as described in the Kjeldahl method. The reagents should be tested by blank experiments.

THE RUFFLE METHOD.

APPARATUS AND RE-AGENTS.

(1) Standard solutions and indicator the same as for the Kjeldahl method.

(2) A mixture of equal parts by weight of fine soda-lime and finely powdered, crystallized sodium hyposulphite.

(3) A mixture of equal parts by weight of finely powdered granulated sugar and flowers of sulphur.

(4) Granulated soda-lime, as described under the soda-lime method.

(5) Combustion tubes of hard Bohemian glass, 20 inches long and $\frac{1}{2}$ inch in diameter.

(6) Bulbed "U" tubes or Wills's bulbs, as described under the soda-lime method.

* Described by Prof. M. A. Scovell.

PREPARATION.

(1) Clean and fill the U tube with 10 cubic centimeters of standard acid.

(2) Fit cork and glass connecting tube. Fill the tube as follows: (1) A loosely fitting plug of asbestos, previously ignited, and then 1 to 1½ inches of the hyposulphite mixture. (2) The weighed portion of the substance to be analyzed is intimately mixed with from 5 to 10 grams of the sugar and sulphur mixture. (3) Pour on a piece of glazed paper, or porcelain mortar, a sufficient quantity of the hyposulphite mixture to fill about 10 inches of the tube; then add the substance to be analyzed, as previously prepared; mix carefully and pour into the tube; shake down the contents of the tube; rinse off the paper or mortar with a small quantity of the hyposulphite mixture and pour into the tube; then fill up with soda-lime to within 2 inches of the end of the tube. (4) Place another plug of ignited asbestos at the end of the tube, and close with a cork. (5) Hold the tube in a horizontal position, and tap on the table until there is a gas channel all along the top of the tube. Make connection with the U tube containing the acid, aspirate, and see that the apparatus is tight.

The combustion.—Place the prepared combustion tube in the furnace, letting the open end project a little so as not to burn the cork. Commence by heating the soda-lime portion until it is brought to a full red heat. Then turn on slowly jet after jet toward the outer end of the tube, so that the bubbles come off two or three a second. When the whole tube is red hot and the evolution of the gas has ceased and the liquid in the U tube begins to recede towards the furnace, attach the aspirator to the other limb of the U tube, break off the end of the tube, and draw a current of air through for a few minutes. Detach the U tube and wash the contents into a beaker or porcelain basin, add a few drops of the cochineal solution, and titrate.

THE SODA-LIME METHOD.

(Not applicable in presence of nitrates.)

APPARATUS AND RE-AGENTS.

(1) Standard solutions and indicator the same as for the Kjeldahl method.

(2) Granulated soda-lime, fine enough to pass a 10-mesh seive, and thoroughly dry.

(3) Fine soda-lime, fine enough to pass a 20-mesh seive, also thoroughly dry.

To prepare soda-lime of the required fineness, the coarse granulated article of the trade may be ground until it will pass through a seive of about .10 inch mesh. It is then sifted on a seive of about .20-inch mesh to separate the fine from the coarse. The two portions are then

thoroughly dried in the air-bath, or by heating in a porcelain dish or iron pan over a lamp, stirring constantly.

Excellent soda-lime may be easily and cheaply prepared according to the directions of Professor Atwater (*Am. Chem. Journal*, vol. 9, p. 312), by slaking $2\frac{1}{2}$ parts of quick-lime with a strong solution of 1 part commercial caustic soda (such soda as is used in the Kjeldahl process), care being taken that there is enough water in the solution to slake the lime. The mixture is then dried and heated in an iron pot to incipient fusion, and when cold, ground and sifted as above.

Instead of soda-lime, Johnson's mixture of carbonate of soda and lime or slaked lime may be used.

Slaked lime may be granulated by mixing it with a little water to form a thick mass, which is dried in the water-oven until hard and brittle. It is then ground and sifted as above. Slaked lime is much easier to work with than soda-lime and gives excellent results, though it is probable that more of it should be used, in proportion to the substance to be analyzed, than is the case with soda-lime.

(4) Asbestos which has been ignited and kept in a glass-stoppered bottle.

(5) Combustion tubes about 40 centimeters long and about 12 millimeters internal diameter, drawn out to a point and closed at one end.

(6) Large bulbed "U" tubes with glass stop-cock, or Wills tubes with four bulbs.

THE DETERMINATION.

The substance to be analyzed should be powdered fine enough to pass through a sieve of 1 millimeter mesh; 0.7 to 1.4 grams, according to the amount of nitrogen present, is taken for the determination. Into the closed end of the combustion tube put a small, loose plug of asbestos, and upon it about 4 centimeters of fine soda-lime. In a porcelain dish or mortar mix the substance to be analyzed, thoroughly but quickly, with enough fine soda-lime to fill about 16 centimeters of the tube, or about 40 times as much soda-lime as substance, and put the mixture into the combustion tube as quickly as possible by means of a wide-necked funnel, rinsing out the dish and funnel with a little more fine soda lime, which is to be put in on top of the mixture. Fill the rest of the tube to about 5 centimeters of the end with a granulated lime, making it as compact as possible by tapping the tube gently, while held in a nearly upright position during the filling. The layer of granulated soda-lime should be not less than 12 centimeters long. Lastly, put in a plug of asbestos about 2 centimeters long, pressed rather tightly, and wipe out the end of the tube to free it from adhering soda-lime.

Connect the tube by means of a well-fitting rubber stopper or cork with the "U" tube or Wills bulbs containing 10 cubic centimeters

standard acid, and adjust it in the combustion furnace so that the end projects about 4 centimeters from the furnace, supporting the "U" tube or Wills tube suitably. Heat the portion of the tube containing the granulated soda lime to moderate redness, and when this is attained, extend the heat gradually through the portion containing the substance so as to keep up a moderate and regular flow of gases through the bulbs, maintaining the heat of the first part until the whole tube is heated uniformly to the same degree. Keep up the heat until gases have ceased bubbling through the acid in the bulbs and the mixture of substance and soda-lime has become white or nearly so, which shows that the combustion is finished. The combustion should occupy about three-quarters of an hour, or not more than one hour. Remove the heat, and when the tube has cooled below redness, break off the closed tip and aspirate air slowly through the apparatus for two or three minutes to bring all the ammonia into the acid. Disconnect, wash the acid into a beaker or flask, and titrate with the standard alkali.

During the combustion, the end of the tube projecting from the furnace must be kept heated sufficiently to prevent the condensation of moisture, yet not enough to char the stopper. The heat may be regulated by a shield of tin slipped over the projecting end of the combustion tube.

It is found very advantageous to attach a Bunsen valve to the exit tube, allowing the evolved gases to pass out freely, but preventing a violent "sucking back" in case of a sudden condensation of steam in the bulbs.

METHOD FOR THE ANALYSIS OF CATTLE FOOD.

Hygroscopic moisture.—Dry 2 to 3 grams at 100° C. to constant weight.

Ash.—Char the substance at a low red heat, exhaust the charred mass with water, burn the insoluble residue, add the ash to the residue from the evaporation of the aqueous extract obtained above, dry the whole at 110°, and weigh. Determine carbonic acid and insoluble matter (sand and charcoal) in the product for the estimation of the pure ash.

Ether extract.—Pulverize the air-dry substance till all of it will pass through a sieve with less than one-sixtieth inch mesh; dry about 5 grams at 100°, and take about 2 grams for each extraction. Exhaust with anhydrous ether of specific gravity .720 to .725, not less than eight hours continuously. Dry ether extract at 100° in a current of dry hydrogen to a constant weight.

Crude protein.—Determine nitrogen by the Kjeldahl method in the manner recommended by the nitrogen committee, and multiply the result by 6.25 for the crude protein.

Albuminoid nitrogen, Stutzer's method.—Prepare cupric hydrate as follows: Dissolve 100 grams of pure cupric sulphate in 5 liters of water and add 2.5 cubic centimeters of glycerine; add dilute solution of sodium hydrate till the liquid is alkaline, filter, rub the precipitate up with water containing 5 cubic centimeters of glycerine per liter, and then wash by decantation or filtration till the washings are no longer alkaline. Then rub the precipitate up again in a mortar with water containing 10 per cent. of glycerine, thus preparing a uniform gelatinous mass that can be measured out with a pipette. Determine the quantity of cupric hydrate per 1 cubic centimeter of this mixture.

To 1 gram of the substance, pulverized as for the determination of the ether extract, add 100 cubic centimeters of water in a beaker, heat to boiling, or in case of substances rich in starch heat on the water bath ten minutes, add a quantity of the cupric hydrate mixture containing 0.7 to 0.8 gram of the hydrate, stir thoroughly, filter when cold, wash with cold water, and without drying put the filter and its contents into the concentrated sulphuric acid for the determination of the nitrogen after Kjeldahl. For filtering use either Schleicher and Shull's No. 589 filter paper or Swedish paper, either of which contains so little nitrogen that it can be left out of account.

If the substance examined consists of seed of any kind or residues of seeds, such as oil-cake or anything rich in alkaline phosphate, add a few cubic centimeters of a concentrated solution of alum just before adding the cupric hydrate, and mix well by stirring. This serves to decompose the alkaline phosphate, precipitating aluminum phosphate; if this is not done cupric phosphate and pure alkali may be formed, and the protein copper may be partially dissolved in this alkaline liquid.

Crude fiber, Weende method.—Pulverize as for the ether extract, and extract the fat, at least nearly completely. To 2 grams of the substance in an Erlenmeyer flask add 200 cubic centimeters of boiling 1.25 per cent. sulphuric acid, boil immediately and for thirty minutes continuously with as much rotary motion as may be necessary to keep all the substances that may tend to adhere to the sides of the flask in contact with the liquid, throw on a filter of finest linen, and rinse the flask and wash the contents of the filter thoroughly with boiling water. Wash the contents of the filter back into the flask with 200 cubic centimeters of a 1.25 per cent. solution of sodium hydrate, at once raise to boiling, and boil continuously for thirty minutes with rotary motion as above described, filter through a Gooch crucible or according to some similar device, and wash very thoroughly with boiling water. Such thorough washing has been found to be essential to success. Wash then with alcohol and finally with ether, dry at 110°, weigh, incinerate, and give the loss of weight for crude fiber.

Statement of results.

	In the substance in its natural condition (or as received).	In the dry substance.
Moisture		
Crude ash		
Ether extract		
Crude fiber		
Crude protein		
Nitrogen: Total		
Albuminoid		

METHODS OF ANALYSES OF DAIRY PRODUCTS.**BUTTER.****MICROSCOPIC EXAMINATION.**

Place a small portion of the fresh sample, taken from the inside of the mass, on a slide, add a drop of pure sweet-oil, cover with gentle pressure, and examine with a one-half to one-eighth inch objective for crystals of lard, etc.

Examine same specimen with polarized light and selenite plate without the use of oil.

Pure fresh butter will neither show crystals nor a parti-colored field with selenite. Other fats, melted and cooled and mixed with butter, will usually present crystals and variegated colors with the selenite plate.

SPECIFIC GRAVITY.

Take a specific-gravity flask, not graduated, the stopper of which carries a delicate thermometer, whose bulb occupies sensibly the center of the flask. The thermometer should be first compared with a standard instrument.

Clean the picnometer with water, alcohol, and ether; dry, be careful to remove all the ether vapor, and weigh.

Fill with distilled water, insert stopper, and place in vessel containing water which comes nearly to top of picnometer (without stopper); gradually raise the temperature of water in vessel containing flask until it is 40.5° to 41° C.

The moment the thermometer of the picnometer marks 40° remove the flask, dry carefully, cover capillary safety-tube, and set in balance or desiccator to cool. Weigh when temperature falls nearly to that of balance room. Having determined the titre of the flask, it is to be carefully dried, filled with the melted and filtered fat at a temperature below 40°, and the weight of the fat determined at 40°, as directed above.

Apparatus.—The apparatus consists of (1) an accurate thermometer, for reading easily tenths of a degree; (2) a less accurate thermometer for measuring the temperature of water in the large beaker glass; (3) a tall beaker glass, 35 centimeters high and 10 centimeters in diameter; (4) a test tube 30 centimeters high and 3.5 centimeters in diameter; (5) a stand for supporting the apparatus; (6) some method of stirring the water in the beaker—for example, a blowing bulb of rubber and a bent glass tube extending to near the bottom of the beaker; (7) a mixture of alcohol and water of the same specific gravity as the fat to be examined.

Manipulation.—The disks of the fat are prepared as follows: The melted and filtered fat is allowed to fall from a dropping tube from a height of 15 to 20 centimeters on to a smooth piece of ice floating in water. The disks thus formed are from 1 to $1\frac{1}{2}$ centimeters in diameter and weigh about 200 milligrams. By pressing the ice under the water the disks are made to float on the surface, whence they are easily removed with a steel spatula.

The mixture of alcohol and water is prepared by boiling distilled water and 95 per cent. alcohol for ten minutes to remove the gases which they may hold in solution. While still hot the water is poured into the test-tube already described until it is nearly half full. The test-tube is then filled with the hot alcohol. It should be poured in gently down the side of the inclined tube to avoid too much mixing. If the tube is not filled until the water has cooled the mixture will contain so many air bubbles as to be unfit for use. These bubbles will gather on the disk of fat as the temperature rises and finally force it to the top of the mixture.

The test-tube containing the alcohol and water is placed in a vessel containing cold water, and the whole cooled to below 10°C . The disk of fat is dropped into the tube from the spatula, and at once sinks until it reaches a part of the tube where the density of the alcohol-water is exactly equivalent to its own. Here it remains at rest and free from the action of any force save that inherent in its own molecules.

The delicate thermometer is placed in the test-tube and lowered until the bulb is just above the disk. In order to secure an even temperature in all parts of the alcohol mixture in the vicinity of the disk the thermometer is moved from time to time in a circularly pendulous manner. A tube prepared in this way will be suitable for use for several days; in fact, until the air bubbles begin to attach themselves to the disk of fat. In no case did the two liquids become so thoroughly mixed as to lose the property of holding the disk at a fixed point, even when they were kept for several weeks.

In practice, owing to the absorption of air, it has been found necessary to prepare new solutions every third or fourth day.

The disk having been placed in position, the water in the beaker-glass

is slowly heated and kept constantly stirred by means of the blowing apparatus already described.

When the temperature of the alcohol-water mixture rises to about 6° below the melting-point, the disk of fat begins to shrivel, and gradually rolls up into an irregular mass.

The thermometer is now lowered until the fat particle is even with the center of the bulb. The bulb of the thermometer should be small, so as to indicate only the temperature of the mixture near the fat. A gentle rotary movement should be given to the thermometer bulb, which might be done with a kind of clockwork. The rise of temperature should be so regulated that the last 2° of increment require about ten minutes. The mass of fat gradually approaches the form of a sphere, and when it is sensibly so the reading of the thermometer is to be made. As soon as the temperature is taken the test-tube is removed from the bath and placed again in the cooler. A second tube, containing alcohol and water, is at once placed in the bath. It is not necessary to cool the water in the bath. The test-tube (ice water being used as a cooler) is of low enough temperature to cool the bath sufficiently. After the first determination, which should be only a trial, the temperature of the bath should be so regulated as to reach a maximum about $1^{\circ}.5$ above the melting-point of the fat under examination.

Working thus with two tubes about three determinations can be made in an hour.

After the test-tube has been cooled the globule of fat is removed with a small spoon attached to a wire before another disk of fat is put in.

VOLATILE ACIDS.

Take about 2.5 grams filtered fat in 200 cubic centimeters flask, to be used in subsequent distillation; add 2 cubic centimeters aqueous solution potassium hydrate containing .5 gram KOH per cubic centimeter. Add 2 cubic centimeters 95 per cent. alcohol and heat on water bath, with occasional agitation. Saponification is complete in a few minutes. Evaporate until alcohol is all driven off, using a current of air to remove alcoholic vapor. The flask is fitted with a delivery tube and condenser. The delivery tube is carried up about 8 inches before it is bent to enter the condenser, and a bulb is blown in it just below the elbow, and this is filled with broken glass or glass-wool.

The fatty acids are then set free with 20 cubic centimeters of a solution of phosphoric acid made by dissolving 200 grams glacial phosphoric acid in water and making up to 1 liter. Enough water is added to make the volume of liquid in the flask 70 cubic centimeters. Distillation is continued until the distillate measures 50 cubic centi-

meters, which is titrated with $\frac{N}{10}$ NaOH, using phenol-phthalein as indicator.

(Care should be taken to have the potash used free from carbonate.

A potash containing carbonate saponifies a fat with great difficulty. In an instance where the saponification was taking place very slowly, the potash was found to contain 6.80 per cent. CO_2 , equal to 21.17 per cent. K_2CO_3 .)

SOLUBLE ACIDS.

The washings obtained in the process of estimating the insoluble acids, the description of which follows, are made up to 1 liter and an aliquot part taken for titration with one-tenth N alkali, using phenolphthalein as indicator.

METHOD FOR THE DETERMINATION OF SOLUBLE AND INSOLUBLE ACIDS.

RE-AGENTS.

1. A standard semi-normal hydrochloric-acid solution, accurately prepared.

2. A standard decinormal soda solution, accurately prepared; each 1 cubic centimeter, contains .0040 gram of NaOH , and neutralizes .0088 gram of butyric acid, $\text{C}_4\text{H}_7\text{O}_2$.

3. An approximately semi-normal alcoholic potash. Dissolve 40 grams of good stick potash in 1 liter of 95 per cent. alcohol, redistilled. The solution must be clear and the KOH free from carbonates.

4. A 1 per cent solution of phenolphthalein in 95 per cent. alcohol.

Saponification is carried out in rubber-stoppered beer-bottles holding about 250 cubic centimeters.

About 5 grams of the melted butter fat, filtered and freed from water and salt, are weighed out by means of a small pipette and beaker, which are reweighed after the sample has been taken out and run into a saponification bottle; 5 cubic centimeters of the semi-normal potash is added, the bottle closed and placed on the steam bath until the contents are entirely saponified, facilitating the operation by occasional agitation. The alcoholic potash is measured always in the same pipette and uniformity further insured by always allowing it to drain the same length of time, viz, thirty seconds. Two or three blanks are also measured out at the same time and treated in the same way.

In from five to thirty minutes, according to the nature of the fat, the liquid will appear perfectly homogeneous, and when this is the case the saponification is complete, and the bottle may be removed and cooled. When sufficiently cool the stopper is removed and the contents of the flask rinsed with a little 95 per cent. alcohol into an Erlenmeyer flask of about 250 cubic centimeters capacity, which is placed on the steam bath, together with the blanks, until the alcohol has evaporated.

Titrate the blanks with semi-normal HCl , using phenolphthalein as an indicator. Then run into each of the flasks containing the fat acids 1 cubic centimeter more semi-normal HCl than is required to neutral-

ize the potash in the blanks. The flask is then connected with a condensing tube 3 feet long, made of small glass tubing, and placed on the steam bath until the separated fatty acids form a clear stratum on the surface of the liquid. The flask and contents are then allowed to become thoroughly cold, ice water being used for cooling.

The fatty acids having quite solidified, the contents of the flask are filtered through a dry filter paper into a liter flask, care being taken not to break the cake. Two hundred to three hundred cubic centimeters of hot water is next poured on the contents of the flask, the cork with its condenser tube re-inserted, and heated on the steam bath until the cake of acids is thoroughly melted, the flask being occasionally agitated with a circular motion, so that none of its contents are brought on the cork. When the fatty acids have again separated as an oily layer the flask and its contents are cooled in ice water, and the liquid filtered through the same filter into the same liter flask. This treatment with hot water, followed by cooling and filtration of the wash water, is repeated three times, the washings being added to the first filtrate. The mixed washings and filtrate are next made up to 1 liter, and 100 cubic centimeters, in duplicate, are taken and titrated with decinormal NaOH. The volume required is calculated to the whole liquid. The number so obtained represents the measure of decinormal NaOH neutralized by the soluble fatty acids of the butter fat taken, plus that corresponding to the excess of the standard acid used, viz, 1 cubic centimeter. The amount of soda employed for the neutralization is to be diminished, for the 1 liter, by 5 cubic centimeters, corresponding to the excess of 1 cubic centimeter $\frac{1}{2}$ N. acid.

This corrected volume, multiplied by the factor 0.0088, gives the butyric acid in the weight of butter fat employed. (See table.)

The flask containing the cake of insoluble fat acids is inverted and allowed to drain and dry for twelve hours, together with the filter paper through which its soluble fatty acids have been filtered. When dry the cake is broken up and transferred to a weighed glass evaporating dish. Remove from the dried filter paper as much of the adhering fat acids as possible and add them to the contents of the dish. The funnel, with the filter paper, is then placed in an Erlenmeyer flask, a hole is made in the bottom of the filter paper, and it is thoroughly washed with absolute alcohol from a wash-bottle. The flask is rinsed with the washings from the filter paper and pure alcohol, and these transferred to the evaporating dish. The dish is placed on the steam bath and the alcohol driven off. It is then transferred to the air bath and dried at 100° C. for two hours, taken out, cooled in a desiccator, and weighed. It is then again placed in the air bath and dried for another two hours, cooled as before, and weighed. If there is no considerable decrease in weight the first weight will do; otherwise, reheat two hours and weigh. This gives the weight of insoluble fat acids in the quantity taken, from which the percentage is easily calculated.

Table for the calculation of soluble fatty acids.

No. cc. KOH sol.	Equiv.	N 10 NaOH.	Equiv.	N 10 NaOH.	Equiv.	N 10 NaOH.	Equiv.
	Grams.		Grams.		Grams.		Grams.
10	.088	+ .25	.0902	+ .50	.0921	+ .75	.0946
11	.0968	25	.0990	50	.1012	75	.1034
12	.1056	25	.1078	50	.1100	75	.1122
13	.1144	25	.1166	50	.1188	75	.1210
14	.1232	25	.1254	50	.1276	75	.1298
15	.1320	25	.1342	50	.1364	75	.1386
16	.1408	25	.1430	50	.1452	75	.1474
17	.1496	25	.1518	50	.1540	75	.1562
18	.1584	25	.1606	50	.1628	75	.1650
19	.1672	25	.1694	50	.1716	75	.1738
20	.1760	25	.1782	50	.1804	75	.1826
21	.1848	25	.1870	50	.1892	75	.1914
22	.1936	25	.1958	50	.1980	75	.2002
23	.2024	25	.2046	50	.2068	75	.2090
24	.2112	25	.2134	50	.2156	75	.2178
25	.2200	25	.2222	50	.2244	75	.2266
26	.2288	25	.2310	50	.2332	75	.2354
27	.2376	25	.2398	50	.2420	75	.2442
28	.2464	25	.2486	50	.2508	75	.2530
29	.2552	25	.2574	50	.2596	75	.2618
30	.2640	25	.2662	50	.2684	75	.2706

The table gives the weight of soluble fatty acids (butyric, etc.) for each quarter of a cubic centimeter of decinormal alkali from 10 to 30.

Example: Weight fat taken.....grams.. 4.967

No. cubic centimeters $\frac{N}{10}$ alkali used..... 25.50

Less 5 cubic centimeters due to 1 cubic centimeter $\frac{N}{2}$ acid..... 20.50

Weights soluble fat acids 1.804

Per cent. soluble fat acids..... 3.63

SAPONIFICATION EQUIVALENT.

About 2.5 grams butter fat (filtered and free from water) are weighed into a patent rubber-stoppered bottle, and 25 cubic centimeters approximately semi-normal alcoholic potash added. The exact amount taken is determined by weighing a small pipette with the beaker of fat, running the fat into the bottle from the pipette and weighing beaker and pipette again. The alcoholic potash is measured always in the same pipette, and uniformity further insured by always allowing it to drain the same length of time (thirty seconds). The bottle is then placed in the steam bath, together with a blank, containing no fat. After saponification is complete and the bottles cooled, the contents are titrated with accurately semi-normal hydrochloric acid, using phenol-phthalein as an indicator. The number of cubic centimeters of the acid used for the sample deducted from the number required for the blank gives the number of cubic centimeters which combines with the fat, and the saponification equivalent is calculated by the following formula, in which W equals the weight of fat taken in milligrams and N the number of cubic centimeters which have combined with the fat.

$$\text{Sap. Equiv.} = \frac{2W}{N}$$

If it is desirable to express the number of milligrams of potash for each gram of fat employed it can be done by dividing 5,610 by the saponification equivalent and multiplying the quotient by ten.

WATER.

Place about 2 grams in flat-bottomed platinum dish two-thirds full of clean, dry sand and heat for two hours in air bath at 105° C. (For alternate method of estimation of water, see page 31.)

ESTIMATION OF SALT.

Volumetric method.—The amount of the butter or butter substitute to be taken is 5–10 grams; weigh in a counterpoised beaker-glass. The butter (fresh from the refrigerator) is placed in portions of about 1 gram at a time in the beaker, these portions being taken from different parts of the sample. By this means a reasonably fair sample of the whole is obtained.

The given quantity having been weighed out, it is removed from the pan.

Hot water is now added (about 20 cubic centimeters) to the beaker, containing the butter, and after it has melted the liquid is poured into the bulb of the separating apparatus. The stopper is now inserted and the contents shaken for a few moments.

After standing until the fat has all collected on top of the water, the stop-cock is opened and the water, containing most of the salt, is allowed to run into an Erlenmeyer flask, being careful to let none of the fat globules pass.

Hot water is again added to the beaker and thence poured into the separatory apparatus, the bottle well shaken, and the foregoing process is repeated ten to fifteen times, using each time 10 to 20 cubic centimeters of water.

The resulting washings contain all but a mere trace of the NaCl, originally present in the butter.

Estimation of NaCl in filtrate.—The chloride of sodium is now determined in the filtrate by a standard solution of AgNO₃, using a few drops of a saturated solution of potassium chromate as indicator.

TOTAL MINERAL MATTER. (ASH) AND CURD.

The methods of estimating curd depend on the principle of first drying a weighed portion of the butter, and afterwards extracting the fat with ether or petroleum. The residual mass is then weighed and the curd determined by loss on ignition. This process is carried on as follows:

Five to ten grams of butter are dried, at 100° C., for a few hours in a porcelain dish. The dried fat, &c., is filtered through a Gooch crucible, the contents of the dish all brought into the crucible and well washed with ether or light petroleum. The filter crucible is dried for two hours in air bath and weighed. The curd is then determined by loss of weight on ignition.

The total mineral matter is represented by the residue left after ignition.

Curd and insoluble substances may be estimated somewhat more accurately as follows :

Place the butter (5 to 10 grams) in a Gooch crucible ; set the crucible on a pad of blotting-paper in an air bath ($100^{\circ}\text{C}.$) for an hour, wash two or three times with ether or light petroleum. Dissolve the salt with hot water, dry at $100^{\circ}\text{C}.$ and weigh. Any insoluble mineral matter and the ash of the curd is weighed with it in this method.

CASEIN.

Method of Babcock.—Ten grams of the dried butter are treated with light petroleum until all fat is removed. The residue is then ignited with soda-lime or treated by the Kjeldahl method.

METHODS FOR MILK ANALYSIS.

ESTIMATION OF WATER.

From a weighing bottle take 5 cubic centimeters milk, put in a weighed thin glass dish or dish lined with tinfoil one-third full of powdered asbestos ; dry for two hours at $100^{\circ}\text{C}.$ The temperature obtained in a boiling-water bath does not reach $100^{\circ}\text{C}.$ The milk should be dried in an air bath, the temperature of which is carefully controlled.

ALTERNATE METHOD OF ESTIMATING WATER.

Evaporate 1 to 2 grams of milk in shallow watch glass or platinum dish on the water bath for thirty minutes. Dry for an hour at $100^{\circ}\text{C}.$ and weigh.

ESTIMATION OF CASEIN.

Take 5 grams of milk, digest in Kjeldahl apparatus with 20 cubic centimeters H_2SO_4 , and estimate ammonia in the usual way.

ALTERNATE METHOD OF ESTIMATION OF CASEIN.

Rub up in a mortar the thin disk containing the dried residue from the above process or remove the foil containing it and transfer to soda-lime combustion tube in the usual way.

The mortar and pestle must be well cleaned with the soda-lime and these cleanings placed in the tube.

Or the dish or tinfoil and its contents may be transferred to a digestion flask and the casein estimated by the method of Kjeldahl.

ESTIMATION OF FAT.

Method of Adams.—The kind of paper and the method of using it first proposed by Adams are as follows :

As for material, the only extra article is some stout white blotting-paper, known in the trade as "white demy blotting mill 428," weighing 38 pounds per ream. This

should be in unfolded sheets, machine-cut into strips $2\frac{1}{2}$ inches wide and 22 inches long; each sheet in this manner cuts into seven strips.

I have tried other papers, but none have answered so well as this; it is very porous and just thick enough. Each of these strips is carefully rolled into a helical coil, for which purpose I use a little machine, made by myself, consisting of a stout double wire, cranked twice at right angles, and mounted in a simple frame. One end of the strip being thrust between the two wires, the handle is turned and the coil made with great facility. This may be done, for the nonce, on a glass rod, the size of a cedar pencil. Two points have to be carefully attended to; the paper must not be broken, and the coil must be somewhat loose, the finished diameter being a little under an inch. I am in the habit of rolling up a considerable number at a time and placing each within a brass ring as it is rolled, inscribing on one corner with a lead-pencil its own proper number.

These coils are next thoroughly dried, and I need hardly say the accuracy of the process depends upon this drying. This can be satisfactorily done in an ordinary air bath at 100° C., providing the bath be heated properly and the paper kept in it long enough. I found the common way of heating the thin bottom of the bath with a single jet not to answer. My bath is placed upon a stout iron surface, which is heated by a large ring of jets; in this way the heat is evenly distributed over the whole of the bottom of the bath, and the papers, which are put in a cage frame of tinned-iron wire 5 by $2\frac{1}{2}$ inches and divided into eight partitions, get evenly and completely dried, if allowed to remain in the bath all night, and weighed in a weighing tube next morning, and their weights having been registered according to their numbers, stored away ready for use, as follows:

The milk to be examined is shaken, and with a pipette 5 cubic centimeters are discharged into a small beaker 2 inches high by $1\frac{1}{2}$ inches in diameter, of a capacity of about 30 cubic centimeters, weighing about 12 grams. This charged beaker is first weighed and then a paper coil gently thrust into the milk very nearly to the bottom. In a few minutes the paper sucks up nearly the whole of the milk. The paper is then carefully withdrawn by the dry extremity of the coil and gently reversed and stood, dry end downwards, on a clean sheet of glass. With a little dexterity all but the last fraction of a drop can be removed from the beaker and got on the paper. The beaker is again weighed and the milk taken got by difference. It is of importance to take up the whole of the milk from the beaker, as I am disposed to consider the paper has a selective action, removing the watery constituents of the milk by preference over the fat.

The charged paper is next placed in the water oven on the glass plate, milk-end upwards, and rough-dried. Mismanagement may possibly cause a drop to pass down through the coil onto the glass. This accident ought never to occur; but if it does it is revealed in a moment by inspection of the surface of the glass, and the experiment is thereby lost.

In about an hour it is rough-dried and in a suitable condition for the extraction of the fat.

The method of Adams has been thoroughly tried by the English chemists and has received the approval of the English Society of Public Analysts. It gives uniformly about .2 per cent. more fat in normal milk than the ordinary gravimetric methods.

The following modification of the process may be used:

The blotting-paper is replaced by thick filtering paper cut into strips 2 feet long and 2.5 inches wide. These are thoroughly extracted by ether or petroleum or alcohol.

One end of the strip of paper being held horizontally by a clamp or by an assistant, 5 cubic centimeters milk is run out by a pipette from a weighing bottle along the middle of the strip of filtering paper, being careful not to let the milk get too near

the ends of the paper and to secure an even distribution of it over the whole length of the slip. The pipette is replaced in the weighing bottle and the whole reweighed, and thus the quantity of milk taken is accurately determined. The strip of paper is now hung up over a sand bath in an inclosed space high enough to receive it where the air has a temperature of 100° C. (*circa*). In two or three minutes the paper is thoroughly dry. It is at once, while still hot, rolled into a coil and placed, before cooling, in the extraction apparatus already described.

The fat is dissolved by ether or petroleum, collected in a weighed flask, and, after thorough drying, weighed.

The fat after extraction may also be estimated volumetrically, as described in the method of Morse.

From data which have been collected, it appears that the estimation of the fat in milk by the lactocrite is strictly comparable with the results of the Adams method. Those who have this instrument, therefore, can use it instead of the method given.

ALTERNATE METHOD OF ESTIMATING THE FAT IN MILK.

Method of Morse, Piggot, and Burton.—This method consists in the dehydration of the milk by means of anhydrous sulphate of copper; the extraction of the fat by means of the low-boiling products of petroleum; the saponification of the butter by means of an excess of a standard solution of potassium hydroxide in alcohol; and the determination of the excess of the alkali by means of a solution of hydrochloric acid. The following apparatus and re-agents are required:

- (1) A porcelain mortar and pestle.
- (2) An extraction tube, 14 or 15 millimeters in diameter, 220 millimeters in length, with funnel-shaped top. A straight chloride of calcium tube may be used for this.
- (3) A 200 cubic centimeter Erlenmeyer flask, strong enough to be used with a filter pump.
- (4) A suitable stand for holding the flask and extraction tube.
- (5) Ten cubic centimeter pipettes.
- (6) Weighing glasses with ground-glass stoppers.
- (7) A low-boiling gasoline, distilling between 30° and 60° C.
- (8) Dehydrated sulphate of copper.
- (9) Semi-normal solution of potash in 95 per cent. alcohol.
- (10) A semi-normal solution of hydrochloric acid.

Manipulation.—Place about 20 grams of the anhydrous copper sulphate, roughly measured in a copper spoon of the size to hold about that amount, in a porcelain mortar; make a cavity in the center of the mass with the pestle. Allow 10 cubic centimeters of the milk to run on to the copper sulphate, being careful that none of it touches the sides of the mortar. When the milk is nearly dry, grind the mass up with a little clean sand, transfer to the extraction tube, gently pressing it down in the tube by means of a glass rod. The lower portion of the extraction tube to be packed with clean cotton wool. The fat is extracted in the following way: 15 cubic centimeters of benzine are poured over the

material in the extraction tube and drawn down, with the aid of the filter pump, until the whole of the mass to be extracted has become wet with the liquid, when the connection with the pump is closed; after about five minutes another portion of 15 cubic centimeters of benzine is poured into the tube and the whole of the liquid slowly drawn through with aid of the pump into the flask. Usually one extraction of this kind is sufficient to withdraw the whole of the butter, but for the sake of greater accuracy the process may be repeated two or three times.

Titration.—The benzine may be evaporated and the residual butter fat saponified with about 25 cubic centimeters of the approximately semi-normal potash. The residual alkali is determined by means of the semi-normal hydrochloric acid, using phenol-phthalein as indicator. The difference between the amount required in this process and the amount necessary to neutralize the quantity of alkali taken gives the amount of alkali required for the saponification. The number of milligrams of potash required for one gram of the fat is taken at 230. The fat may also be accurately titrated without evaporating the benzine.

ALTERNATE METHOD OF ESTIMATING WATER AND FAT IN MILK.

Method of Babcock.—In the bottom of a perforated test-tube is placed a clump of clean cotton; the tube is then filled three-quarters full of ignited asbestos, lightly packed, and a plug of cotton inserted over it. The tube and contents are weighed and the plug of cotton carefully removed and 5 grams of milk from a weighed pipette run into it, and the plug of cotton replaced. The tube connected at its lower end by a rubber tube and adapter with a filter pump is placed in a drying oven of a 100° C., and a slow current of dry air drawn through it until the water is completely expelled, which in no case requires more than two hours.

The tube containing the solids from the above operation is placed in an extraction apparatus and exhausted with ether in the usual way.

ALTERNATE METHOD OF ESTIMATING WATER AND FAT.

Method of Professor Macfarlane.—A glass tube 4 to 5 cubic centimeters in length and 2 centimeters in diameter, open at one end, drawn out to a tube 5 millimeters in diameter at the other end, is two-thirds filled with asbestos fiber, such as is used in manufacturing packing. It is dried in the water bath for several hours, cooled in the desiccator, and weighed. Ten cubic centimeters of the milk is then added from a pipette, which is completely absorbed by the asbestos. It is then weighed, the additional weight of the milk representing the amount taken. The tube, along with many others, is placed in a water bath with constant level and dried for ten or twelve hours (during the night) at a temperature of 90°. Next morning the tubes are cooled in the desiccator and weighed, the loss in weight being the moisture. The tubes are then placed in the Soxhlet extraction apparatus and exhausted with petroleum ether for

four hours. They are then removed and dried in a steam bath, cooled in desiccator, and weighed. The loss represents the butter fat.

THE ESTIMATION OF SUGAR.

The re-agents, apparatus, and manipulation necessary to give the most reliable results in milk sugar estimation are as follows:

Re-agents.—(1) *Basic plumbic acetate*, specific gravity 1.97. Boil a saturated solution of sugar of lead with an excess of litharge, and make it of the strength indicated above. One cubic centimeter of this will precipitate the albumens in 50 to 60 cubic centimeters of milk.

(2) *Acid mercuric nitrate*. Dissolve mercury in double its weight of nitric acid, specific gravity 1.42. Add to the solution an equal volume of water. One cubic centimeter of this re-agent is sufficient for the quantity of milk mentioned above. Larger quantities can be used without affecting the results of polarization.

(3) *Mercuric iodide with acetic acid*. KI 33.2 grams, HgCl_2 13.5 grams, H_2O 20 cubic centimeters, H_2O 64 cubic centimeters.

Apparatus.—(1) Pipettes marked at 59.5, 60, and 60.5 cubic centimeters. (2) Sugar flasks marked at 102.4 cubic centimeters. (3) Filters, observation tubes, and polariscope. (4) Specific gravity spindle and cylinder. (5) Thermometers.

Manipulation.—(1) The room and milk should be kept at a constant temperature. It is not important that the temperature should be any given degree. The work can be carried on equally well at 15°C ., 20°C ., or 25°C . The slight variations in rotatory power within the above limits will not affect the result for analytical purposes. The temperature selected should be the one which is most easily kept constant.

(2) The specific gravity of the milk is determined. For general work this is done by a delicate specific-gravity spindle. Where greater accuracy is required, use specific-gravity flask.

(3) If the specific gravity be 1.026, or nearly so, measure out 60.5 cubic centimeters into the sugar-flask. Add 1 cubic centimeter of mercuric nitrate solution, or 30 cubic centimeters mercuric iodide solution, and fill to 102.4 cubic-centimeter mark. The precipitated albumen occupies a volume of about 2.44 cubic centimeters. Hence the milk solution is really 100 cubic centimeters. If the specific gravity is 1.030, use 60 cubic centimeters of milk. If specific gravity is 1.034, use 59.5 cubic centimeters of milk.

(4) Fill up to mark in 102.4 cubic-centimeter flask, shake well, filter, and polarize.

NOTES.—In the above method of analysis the specific rotatory power of milk sugar is taken at 52.5, and the weight of it in 100 cubic centimeter solution to read 100 degrees in the cane-sugar scale at 20.56 grams. This is for instruments requiring 16.19 grams sucrose to produce a rotation of 100 sugar degrees. It will be easy to calculate the number for milk-sugar, whatever instrument is employed.

Since the quality of milk taken is three times 20.56 grams, the polariscopic readings divided by 3 give at once the percentage of milk sugar when a 200-millimeter tube is used.

If a 400-millimeter tube is employed, divide reading by 6; if a 500-millimeter tube is used, divide by 7.5.

Since it requires but little more time, it is advisable to make the analysis in duplicate and take four readings for each tube. By following this method gross errors of observation are detected and avoided.

By using a flask graduated at 102.4 for 60 cubic centimeters no correction for volume of precipitated caseine need be made. In no case is it necessary to heat the sample before polarizing.

In the above method no account is taken of the fat which is retained on the filter with the caseine. It is worth while to inquire if a correction similar to that made for the albuminoids should not also be made for the fat? (See page 10, Vieth's Investigation of this subject from Analyst 13, 63.)

ESTIMATION OF ASH.

Evaporate to dryness in a weighed platinum dish 20 cubic centimeters of milk from a weighing-bottle, to which 6 cubic centimeters of HNO_3 has been added, and burn in muffle at low red heat until ash is free from carbon.

METHODS FOR THE ANALYSIS OF FERMENTED LIQUORS.

A commission of experts, appointed in the year 1884 by the chancellor of the Empire, to which was intrusted the establishment of uniform methods for the chemical investigation of wine, adopted the following resolutions, which were made public by the Prussian minister for commerce and trade by a decree of the 12th August, 1884, which provides that they shall be rigidly adhered to in public institutions for the examination of food-stuffs, and are recommended to the representatives of like private concerns:

RESOLUTIONS OF THE COMMISSION FOR ESTABLISHING UNIFORM METHODS FOR THE ANALYSIS OF WINES.¹

Since, in consequence of improper manner of taking, keeping, and sending in of samples of wine for investigation by the authorities, a decomposition or change in the latter often occurs, the commission considers it advisable to give the following instructions:

INSTRUCTIONS FOR SAMPLING, PRESERVING, AND SENDING IN OF SAMPLES OF WINE FOR EXAMINATION BY THE AUTHORITIES.

(1) Of each sample, at least one bottle ($\frac{1}{2}$ liter), as well filled as possible, must be taken.

(2) The bottles and corks used must be perfectly clean; the best are new bottles and corks. Pitchers or opaque bottles in which the presence of impurities can not be seen are not to be used.

¹ Das Gesetz betreffend den Verkehr mit Nahrungsmittel, u. s. w., p. 184.

(3) Each bottle shall be provided with a label, gummed (not tied) on, upon which shall be given the index number of the sample corresponding to a description of it.

(4) The samples are to be sent to the chemical laboratory as soon as possible to avoid any chance of alteration which, under some circumstances, can take place in a very short time. If they are, for some special reason retained in any other place for any length of time, the bottles are to be placed in a cellar and kept lying on their sides.

(5) If in samples of wine taken from any business concern adulteration is shown, a bottle of the water is to be taken which was presumably used in the adulteration.

(6) It is advisable, in many cases necessary, that, together with the wine, a copy of these resolutions be sent to the chemist.

A.—Analytical methods.

Specific gravity.—In this determination use is to be made of a pycnometer, or a Westphal balance controlled by a pycnometer. Temperature, 15° C.

Alcohol.—The alcohol is estimated in 50 to 100 cubic centimeters of the wine by the distillation method. The amount of alcohol is to be given in the following way: In 100 cubic centimeters wine at 15° C. are contained n grams alcohol. For the calculation the tables of Baumhauer or Hebner are used.

(The amounts of all the other constituents are also to be given in this way; in 100 cubic centimeters wine at 15° C. are contained n grams.)

Extract.—For this estimation 50 cubic centimeters of wine, measured out at 15° C., are evaporated on the water bath in a platinum dish (85 millimeters in diameter, 20 millimeters in height, and 75 cubic centimeters capacity, weight about 20 grams), and the residue heated for two and one-half hours in a water jacket. Of wines rich in sugar (that is, wines containing over 0.5 grams of sugar in 100 cubic centimeters) a smaller quantity, with corresponding dilution, is taken, so that 1 or at the most 1.5 grams extract are weighed.

Glycerine.—One hundred cubic centimeters of wine (for sweet wines see below) are evaporated in a roomy, not too shallow, porcelain dish to about 10 cubic centimeters, a little sand added, and milk of lime to a strong alkaline reaction, and the whole brought nearly to dryness. The residue is extracted with 50 cubic centimeters of 96 per cent. alcohol on the water bath, with frequent stirring. The solution is poured off through a filter, and the residue exhausted by treatment with small quantities of alcohol. For this 50 to 100 cubic centimeters are generally sufficient, so that the entire filtrate measures 100 to 200 cubic centimeters. The alcoholic solution is evaporated on the water bath to a sirupy consistence. (The principal part of the alcohol may be distilled off if desired.) The residue is taken up by 10 cubic centimeters of absolute alcohol, mixed in a stoppered flask with 15 cubic centimeters of ether and allowed to stand until clear, when the clear liquid is poured off into a glass-stoppered weighing-glass, filtering the last portions of the solution. The solution is then evaporated in the weighing-glass until the residue no longer flows readily, after which it is dried an hour longer in a water jacket. After cooling it is weighed.

In the case of sweet wines (over 0.5 grams sugar in 100 cubic centimeters) 50 cubic centimeters are taken in a good-sized flask, some sand added, and a sufficient quantity of powdered slack lime, and heated with frequent shaking in the water bath. After cooling, 100 cubic centimeters of 96 per cent. alcohol are added, the precipitate which forms allowed to separate, the solution filtered, and the residue washed with alcohol of the same strength. The alcoholic solution is evaporated and the residue treated as above.

Free acids (total quantity of the acid reacting constituents of the wine).—These are to be estimated with a sufficiently dilute normal solution of alkali (at least one-third normal alkali) in 10 to 20 cubic centimeters wine. If one-tenth normal alkali is used at least 10 cubic centimeters of wine should be taken for titration; if one-third normal, 20 cubic centimeters of wine. The drop method (*Tupfel methode*), with delicate

re-agent paper, is recommended for the establishment of the neutral point. Any considerable quantities of carbonic acid in the wine are to be previously removed by shaking. These "free acids" are to be reckoned and reported as tartaric acid ($C_4H_6O_6$).

Volatile acids.—These are to be estimated by distillation in a current of steam, and not indirectly, and reported as acetic acid ($C_2H_4O_2$). The amount of the "fixed acids" is found by subtracting from the amount of "free acids" found, the amount of tartaric acid corresponding to the "volatile acids" found.

Bitartrate of potash and free tartaric acid.—(a) Qualitative detection of free tartaric acid: 20 to 30 cubic centimeters of the wine are treated with precipitated and finely-powdered bitartrate of potash, shaken repeatedly, filtered off after an hour, and 2 to 3 drops of a 20 per cent. solution of acetate of potash added to the clear filtrate, and the solution allowed to stand twelve hours. The shaking and standing of the solution must take place at as nearly as possible the same temperature. If any considerable precipitate forms during this time free tartaric acid is present, and the estimation of it and of the bitartrate of potash may be necessary.

(b) Quantitative estimation of the bitartrate of potash and free tartaric acid: In two stoppered flasks two samples of 20 cubic centimeters of wine each are treated with 200 cubic centimeters ether-alcohol (equal volumes), after adding to the one flask 2 to 3 drops of a 20 per cent. solution of acetate of potash. The mixtures are well shaken, and allowed to stand sixteen to eighteen hours at a low temperature ($0-10^\circ C.$), the precipitate filtered off, washed with ether-alcohol, and titrated. (The solution of acetate of potash must be neutral or acid. The addition of too much acetate may cause the retention of some bitartrate in solution.) It is best on the score of safety to add to the filtrate from the estimation of the total tartaric acid a further portion of 2 drops of acetate of potash, to see if a further precipitation takes place.

In special cases the following procedure of Nessler and Barth may be used as a control:

Fifty cubic centimeters of wine are evaporated to the consistency of a thin sirup (best with the addition of quartz sand), the residue brought into a flask by means of small washings of 96 per cent. alcohol, and with continual shaking more alcohol is gradually added, until the entire quantity of alcohol is about 100 cubic centimeters. The flask and contents are corked and allowed to stand four hours in a cool place, then filtered, and the precipitate washed with 96 per cent. alcohol; the filter paper, together with the partly flocculent, partly crystalline precipitate, is returned to the flask, treated with 30 cubic centimeters warm water, titrated after cooling, and the acidity reckoned as bitartrate. The result is sometimes too high if pectinous bodies separate out in small lumps, inclosing a small portion of free acids.

In the alcoholic filtrate the alcohol is evaporated, 0.5 cubic centimeters of a 20 per cent. potassic acetate solution added, which has been acidified by a slight excess of acetic acid, and thus the formation of bitartrate from the free tartaric acid in the wine facilitated. The whole is now, like the first residue of evaporation, treated with (sand and) 96 per cent. alcohol, and carefully brought into a flask, the volume of alcohol increased to 100 cubic centimeters, well shaken, corked, allowed to stand in a cold place four hours, filtered, the precipitate washed, dissolved in warm water, titrated, and for one equivalent of alkali two equivalents of tartaric acid are reckoned.

This method for the estimation of the free tartaric acid has the advantage over the former of being free from all errors of estimation by difference. The presence of considerable quantities of sulphates impairs the accuracy of the method.

Malic acid, succinic acid, citric acid.—Methods for the separation and estimation of these acids can not be recommended at the present time.

Salicylic acid.—For the detection of this, 100 cubic centimeters of wine are repeatedly shaken out with chloroform, the latter evaporated and the aqueous solution of the residue tested with very dilute solution of ferric chloride. For the approximately

quantitative determination it is sufficient to weigh the chloroform residue, after it has been again recrystallized from chloroform.

Coloring matter.—Red wines are always to be tested for coal-tar colors. Conclusions in regard to the presence of other foreign coloring matters drawn from the color of precipitates and other color reactions are only exceptionally to be regarded as safe. In the search for coal-tar colors the shaking out of 100 cubic centimeters of the wine with ether before and after its neutralization with ammonia is recommended. The ethereal solutions are to be tested separately.

Tannin.—In case a quantitative determination of tannin (or tannin and coloring matter) appears necessary, the permanganate method of Neubauer is to be employed. As a rule the following estimation of the amount of tannin will suffice: The free acids are neutralized to within 0.5 grams in 100 cubic centimeters with standard alkali, if necessary. Then 1 cubic centimeter of 40 per cent. sodic acetate solution is added, and drop by drop a 10 per cent. solution of ferric chloride, avoiding an excess. One drop of ferric chloride is sufficient for the precipitation of 0.05 per cent. of tannin. (New wines are deprived of the carbonic acid held in solution by repeated shaking.)

Sugar.—The sugar should be determined, after the addition of carbonate of soda, by means of Fehling's solution, using dilute solutions, and, in wines rich in sugar (*i. e.*, wines containing over .5 gram in 100 cubic centimeters), with observance of Soxhlet's modifications, and calculated as grape sugar. Highly colored wines are to be decolorized with animal charcoal if their content of sugar is low, and with acetate of lead and sodium carbonate if it is high.

If the polarization indicates the presence of cane sugar (compare under polarization) the estimation is to be repeated in the manner indicated after the inversion (heating with hydrochloric acid) of the solution. From the difference the cane sugar can be calculated.

Polarization.—(1) With white wines: 60 cubic centimeters of wine are treated with 3 cubic centimeters acetate of lead solution in a graduated cylinder, and the precipitate filtered off. To 30 cubic centimeters of the filtrate is added 1.5 cubic centimeters of a saturated solution of sodic carbonate, filtered again, and the filtrate polarized. This gives a dilution of 10:11 which must be allowed for.

(2) With red wines: 60 cubic centimeters wines are treated with 6 cubic centimeters acetate of lead, and to 30 cubic centimeters of the filtrate 3 cubic centimeters of the saturated solution of sodic carbonate added, filtered again, and polarized. In this way a dilution of 5:6 is obtained.

The above conditions are so arranged (with white and red wines) that the last filtrate suffices to fill the 220-millimeter tube of the Wild polaristrobometer of which the capacity is about 28 cubic centimeters.

In place of the acetate of lead very small quantities of animal charcoal can be used. In this case an addition of sodic carbonate is not necessary, nor is the volume of the wine altered. If a portion of the undiluted wine 220 millimeters long shows a higher right-handed rotation than 0.3° , Wild, the following procedure is necessary:

Two hundred and ten cubic centimeters of the wine are evaporated on the water bath to a thin sirup, after the addition of a few drops of a 20 per cent. solution of acetate of potash. To the residue is added gradually, with continual stirring, 200 cubic centimeters of 90 per cent. alcohol. The alcoholic solution, when perfectly clear, is poured off or filtered into a flask, and the alcohol distilled or evaporated off down to about 5 cubic centimeters. The residue is treated with about 15 cubic centimeters water and a little bone-black, filtered into a graduated cylinder, and washed with water until the filtrate measures 30 cubic centimeters. If this shows on polarization a rotation of more than $+0.5^\circ$, Wild, the wine contains the unfermentable matter of commercial potato sugar (amylin). If in the estimation of the sugar by Fehling's solution more than 0.3 grams sugar in 100 cubic centimeters was found, the original right-rotation caused by the amylin may be diminished by the left-rotating sugar; the above precipitation with alcohol is in this case to be undertaken, even

when the right-rotation is less than 0.3° , Wild. The sugar is, however, first fermented by the addition of pure yeast. With very considerable content in (Fehling's solution) reducing sugar and proportionally small left-rotation, the diminishing of the left-rotation may be brought about by cane sugar or dextrin or amylin. For the detection of the first the wine is inverted by heating with hydrochloric acid (to 50 cubic centimeters wine, 5 cubic centimeters dilute hydrochloric acid of specific gravity 1.10), and again polarized. If the left-rotation has increased, the presence of cane sugar is demonstrated. The presence of dextrin is shown as given in the section on "gum." In case cane sugar is present well washed yeast, as pure as possible, should be added, and the wine polarized after fermentation is complete. The conclusions are then the same as with the wines poor in sugar.

For polarization only large, exact instruments are to be used.

The rotation is to be calculated in degrees, Wild, according to Landolt (*Zeitschr. f. analyt. Chemie*, 7. 9):

1° Wild	= 4.6043° Soleil.
1° Soleil	= 0.217189° Wild.
1° Wild	= 2.89005° Ventzke.
1° Ventzke	= 0.346015° Wild.

Gum (arabic).—For establishing the addition of any considerable quantities of gum 4 cubic centimeters wine are treated with 10 cubic centimeters of 96 per cent. alcohol. If gum is present, the mixture becomes milky, and only clears up again after several hours. The precipitate which occurs adheres partly to the sides of the tube, and forms hard lumps. In genuine wine, flakes appear after a short time, which soon settle, and remain somewhat loose. For a more exact test it is recommended to evaporate the wine to the consistency of a sirup, extract with alcohol, of the strength given above, and dissolve the insoluble residue in water. This solution is treated with some hydrochloric acid (of specific gravity 1.10) heated under pressure two hours, and the reducing power ascertained with Fehling's solution, and calculated to dextrose. In genuine wines no considerable reduction is obtained in this way. (Dextrin is to be detected in the same way.)

Mannite.—As the presence of mannite in wines has been observed in a few cases, it should be considered when pointed crystals make their appearance in the extract or the glycerine.

Nitrogen.—In the estimation of nitrogen the soda-lime method is to be used.

Mineral matters.—For their estimation 50 cubic centimeters of wine are used. If the incineration is incomplete, the charcoal is leached with some water, and burned by itself. The solution is evaporated in the same dish, and the entire ash gently ignited.

Chlorine estimation.—The wine is saturated with sodic carbonate, evaporated, the residue gently ignited and exhausted with water. In this solution the chlorine is to be estimated volumetrically according to Volhard, or gravimetrically. Wines whose ashes do not burn white by gentle ignition usually contain considerable quantities of chlorine (salt).

Sulphuric acid.—This is to be estimated directly in the wine by the addition of barium chloride. The quantitative estimation of the sulphuric acid is to be carried out only in cases where the qualitative test indicates the presence of abnormally large quantities. (In the case of viscous or very muddy wines a previous clarification with Spanish earth is to be recommended.)

If in a special case it is necessary to investigate whether free sulphuric acid or potassium bisulphate are present, it must be proved that more sulphuric acid is present than is necessary to form neutral salts with all the bases.

Phosphoric acid.—In the case of wines whose ashes do not react strongly alkaline the estimation is made by evaporating the wine with sodic carbonate and potassic nitrate, the residue gently ignited and taken up with dilute nitric acid; then the molybdenum method is to be used. If the ash reacts strongly alkaline the nitric-acid solution of it can be used directly for the phosphoric-acid determination.

The other mineral constituents of wine (also alum) are to be determined in the ash or residue of incineration.

Sulphurous acid.—One hundred cubic centimeters wine are distilled in a current of carbonic acid gas after the addition of phosphoric acid. For receiving the distillate 5 cubic centimeters of normal iodine solution are used. After the first third has distilled off, the distillate, which must still contain an excess of free iodine, is acidified with hydrochloric acid, heated and treated with barium chloride.

Adulteration of grape wine with fruit wine.—The detection of this adulteration can only exceptionally be carried out with certainty by means of the methods that have so far been offered. Especially are all methods untrustworthy which rely upon a single reaction to distinguish grape from fruit wine; neither is it always possible to decide with certainty from the absence of tartaric acid, or from the presence of only very small quantities, that a wine is not made from grapes.

In the manufacture of artificial wine together with water the following articles are known to be sometimes used: Alcohol (direct or in the shape of fortified wine), cane sugar, starch sugar, and substances rich in sugar (honey), glycerine, bitartrate of potash, tartaric acid, other vegetable acids, and substances rich in such acids, salicylic acid, mineral matters, gum arabic, tannic acid, and substances rich in the same (e. g., kino, catechu), foreign coloring matters, various ethers and aromas.

The estimation, or rather the means of detecting the most of these substances has already been given above, with the exception of the aromas and ethers, for which no method can as yet be recommended.

The following substances may be mentioned here in particular, which serve for increasing the sugar, extract and free acid: Dried fruit, tamarinds, St. John's bread, dates, figs.

B.—Rules for judging of the purity of wine.

I. (a) Tests and determinations which are, as a rule, to be performed in judging of the purity of wines: Extract, alcohol, sugar, free acids as a whole, free tartaric acid qualitative, sulphuric acid, total ash, polarization, gum, foreign coloring matters in red wines. (b) Tests and determinations which are also to be carried out under special circumstances: Specific gravity, volatile acids, bitartrate of potash, and free tartaric acid quantitative, succinic acid, malic acid, citric acid, salicylic acid, sulphurous acid, tannin, mannite, special ash constituents, nitrogen.

The commission considers it desirable, in giving the estimations generally performed, to adhere to the order of succession given above, (under (a)).

II. The commission can not regard it as their province to give a guide for judging of the purity of wine, but thinks it advisable, in the light of its experience, to call attention to the following points:

Wines which are made wholly from pure grape juice very seldom contain a less quantity of extract than 1.5 grams in 100 cubic centimeters wine. If wines poorer in extract occur they should be condemned, unless it can be proven that natural wines of the same district and vintage occur with a similar low content of extract.

After subtracting the "fixed acids" the remaining extract (*extractrest*) in pure wines, according to previous experience, amounts to at least 1.1 grams in 100 cubic centimeters, and after subtracting the "free acids," at least 1 gram. Wines which show less *extractrest* are to be condemned, in case it can not be shown that natural wines of the same district and vintage contain as small an *extractrest*.

A wine which contains appreciably more ash than 10 per cent. of its extract content must contain, correspondingly, more extract than would otherwise be accepted as a minimum limit. In natural wines the relation of ash to extract approaches very closely 1 to 10 parts by weight. Still a considerable deviation from this relation does not entirely justify the conclusion that the wine is adulterated.

The amount of free tartaric acid in pure wines, according to previous experience, does not exceed one-sixth of the entire "fixed acids."

The relation between alcohol and glycerine can vary in pure wines between 100 parts by weight of alcohol to 7 parts by weight of glycerine, and 100 parts by weight of alcohol to 14 parts by weight of glycerine. In case of wines showing a different glycerine relation an addition of alcohol or glycerine can be inferred.

As sometimes during its handling in cellars small quantities of alcohol (at most 1 per cent. by volume) may find their way into wine, this fact must be borne in mind in judging of its purity.

These proportions are not always applicable to sweet wines.

For the individual ash constituents no generally applicable limits can be given. The opinion that the better kinds of wine always contain more phosphoric acid than others is unfounded.

Wines that contain less than 0.14 gram of mineral matter in 100 cubic centimeters are to be condemned, if it can not be shown that natural wines of the same kind and the same vintage, which have been subject to like treatment, have an equally small content of mineral matter.

Wines which contain more than 0.05 gram of salt in 100 cubic centimeters are to be condemned.

Wines that contain more than 0.092 gram sulphuric acid (SO_3) corresponding to 0.20 grams potassic sulphate (K_2SO_4) in 100 cubic centimeters, are to be designated as wines containing too much sulphuric acid, either from the use of gypsum or in some other way.

Through various causes wines may become viscous, black, brown, cloudy, or bitter; they may otherwise change essentially in color, taste, and odor. The color of red wines may also separate in a solid form; still all these phenomena in and of themselves would not justify the condemnation of the wine as not genuine.

If during the summer time an energetic fermentation commences in a wine, this does not justify the conclusion that an addition of sugar or substances rich in sugar, e. g., honey, etc., has taken place, for the first fermentation may have been hindered in various ways or the wine may have had an addition of a wine rich in sugar.

The methods adopted by the "Union of Bavarian Chemists" differ considerably from the above in many particulars, so they are given also, together with the methods adopted by the same body for the examination of beer¹ in somewhat condensed form.

WINES.

METHODS OF INVESTIGATION.

I. *Determination of specific gravity.*—This is to be done by means of a Westphal's balance or a pycnometer, and always at 15° C.

II. *Determination of extract.*—Ten to 50 cubic centimeters wine at 15° C. are evaporated in a platinum dish on the water bath to the proper consistence, and then dried in a drying oven at 100° C. to constant loss of weight. Constant loss of weight is assumed when three weighings, with equal intervals between the first and second and second and third give equal differences between the successive weighings.

Weighings are to be made at intervals of fifteen minutes.

III. *Inorganic matter.*—This is the incombustible ash obtained by burning the extract. Repeated moistening, drying, and heating to redness are advisable to entirely get rid of all organic constituents.

IV. *Acidity.*—After shaking vigorously, to drive off carbonic acid, the wine is to be titrated with an alkali solution and the acidity expressed in terms of tartaric acid.

V. *Glycerine.*—(1) This is determined in dry wines as follows: The alcohol is driven off from 100 cubic centimeters wine, lime or magnesia added, and the mass evaporated to dryness. The residue is boiled with 90 per cent. alcohol, filtered, and the

¹ Hilger, Vereinbarungen u. s. w., p. 154.

filtrate evaporated to dryness. This residue is dissolved in 10 to 20 cubic centimeters alcohol, 15 to 30 cubic centimeters ether added, and the mixture allowed to stand until it is clear. It is then decanted from the sticky precipitate into a glass-stoppered weighing-bottle, evaporated to constant loss of weight, and weighed.

(2) The following method is employed for sweet wines: One hundred cubic centimeters wine are measured into a porcelain dish and evaporated on the water bath to a sirupy consistence, mixed with 100 to 150 cubic centimeters absolute alcohol, poured into a flask, ether added in the proportion of 1½ volumes to each volume of alcohol used, the flask well shaken, and allowed to stand until the liquid becomes clear. This is then poured off and the residue again treated with a mixture of alcohol and ether. The liquids are mixed, the alcohol and ether driven off, the residue dissolved in water, and treated as in (1).

(3) In all glycerine determinations it is necessary to take into consideration the loss of glycerine due to its volatility with water and alcohol vapor, and accordingly to add to the glycerine found 0.100 gram for each 100 cubic centimeters of liquid evaporated.

(4) It is necessary to test the glycerine from sweet wines for sugar, and if any is present it must be estimated by Soxhlet's or Knapp's method and its weight subtracted from that of the glycerine.

VI. *Alcohol*.—The determination must be made by distillation in glass vessels, and the results stated as follows: One hundred cubic centimeters wine at 15° C. contain *x* grams or cubic centimeters alcohol.

VII. *Polarization*.—(1) The wine is decolorized with plumbic subacetate.

(2) A slight excess of sodic carbonate is added to the filtrate from (1). Two cubic centimeters of a solution of plumbic subacetate are added to 40 cubic centimeters white wine and 5 cubic centimeters to 40 cubic centimeters red wine, the solution is filtered and 1 cubic centimeter of a saturated solution of sodic carbonate added to 21 or 22.5 cubic centimeters of the filtrate.

(3) The kind of apparatus used and the length of the tube are to be given, and results estimated in equivalents of Wild's polaristrobometer with 200-millimeter tubes.

(4) All samples rotating more than 0.5 degrees to the right (in 220-millimeter tubes, after treating as above), and showing no change, or but little change, in their rotatory power after inversion, are to be considered as containing unfermented glucose (starch sugar) residue.

(5) Rotatory power of less than 0.3 degrees to the right shows that impure glucose has not been added.

(6) Wines rotating between 0.3 degrees and 0.5 degrees to the right must be treated by the alcohol method.

(7) Wines rotating strongly to the left must be fermented and their optical properties then examined.

VIII. *Sugar*.—This is to be determined by Soxhlet's or Knapp's method. The presence of unfermented cane sugar is to be shown by inversion, etc.

IX. *Potassic bitartrate*.—The determination of potassic bitartrate as such is to be omitted.

X. *Tartaric, malic, and succinic acids*.—(1) According to Schmidt and Hiepe's method.

(2) Determination of tartaric acid according to the modified Berthelot-Flenry method.

(3) If the addition of 1 gram finely-powdered tartaric acid to 100 grams wine produces no precipitate of potassic bitartrate, the modified Berthelot-Flenry method must be employed to determine free tartaric acid.

XI. *Coloring matter*.—(1) Only aniline dyes are to be looked for.

(2) Special attention is to be paid to the spectroscopic behavior of rosaniline dyes, as obtained by shaking wines with amyl alcohol before and after saturation with ammonia.

(3) A qualitative test for alumina is not sufficient evidence of the addition of alum.

XII. *Nitrogen*.—To be determined according to the ordinary method.

XIII. *Citric acid*.—Presence to be shown by a qualitative test, as baric citrate.

XIV. *Sulphuric acid*.—To be determined in the wine after adding hydrochloric acid.

XV. *Chlorine*.—To be determined in the nitric-acid solution of the burnt residue by Volhard's method.

XVI. *Lime, magnesia, and phosphoric acid*.—These are determined in the ash fused with sodic hydrate and potassic nitrate, the phosphoric acid by the molybdenum method.

XVII. *Potash*. Either in the wine ash, as the platinum double salt, or in the wine itself, by Kayser's method.

XVIII. *Gums*.—Presence shown by precipitation by alcohol; 4 cubic centimeters wine and 10 cubic centimeters 96 per cent. alcohol are mixed. If gum arabic has been added, a lumpy, thick, stringy precipitate is produced; whereas pure wine becomes at first opalescent and then flocculent.

METHODS OF JUDGING PURITY—(Beurtheilung).

Part I.

I. Commercial wines may be defined as follows: (a) The product obtained by the fermentation of grape juice with or without grape skins and stems. (b) The product obtained by the fermentation of pure must, to which pure sugar, water, or infusion of grape skins has been added. It must contain not more than 9 per cent. alcohol and 0.3 per cent. sugar, and not less than 0.7 per cent. acid, estimated as tartaric. (c) The product obtained in southern countries by the addition of alcohol to fermented or partly fermented grape juice. French wines are not included, however. (d) The product obtained by fermenting the expressed juice of more or less completely dried wine grapes.

II. The above definitions do not apply to champagnes.

III. The following include the operations undergone by wines in cellars (*Keller-mässige Behandlung*): (a) Drawing and filling. (b) Filtration. (c) Clarification by the use of kaolin, isinglass, gelatine or albumin, with or without tannin. (d) Sulphuring. Only minute traces of sulphurous acid may be contained in wine for consumption. (e) Adulteration of wine. (f) Addition of alcohol to wine intended for export.

IV. Wines, even if plastered, must not contain more sulphuric acid than that corresponding to 2 grams potassic sulphate (K_2SO_4) per liter.

V. Medicinal wines are those mentioned in Parts I and IV, with the following restrictions: (a) They must not contain more sulphuric acid than corresponds to 1 gram potassic sulphate per liter. (b) They must contain no sulphurous acid. (c) The percentage of alcohol and sugar to be given on the label. (d) These restrictions apply only to wines expressly recommended or sold for medicinal use.

Part II.

I. Improperly gallized wines are preparations of grape juice, pure sugar and water, or grape-skin infusion, that contain more than 9 per cent. alcohol or less than 0.7 per cent. acid, or both, and preparations in which impure glucose has been used. The following facts enable us to detect them: Small quantity of inorganic matter (phosphoric acid and magnesia), and right rotation if impure glucose is used. If the rotation exceeds 0.2° to the right, the wine is to be concentrated, freed from tartaric acid as far as possible, and again polarized.

II. Addition of alcohol is to be assumed if the ratio of alcohol to glycerine is greater than 10 to 1 by weight.

III. Addition of water and alcohol is recognized by the diminution in the quantity of inorganic matter, especially magnesia, phosphoric acid, and usually potash. Addition of water alone is recognized in the same way.

IV. Scheelization, *i. e.*, addition of glycerine, is assumed if the ratio of glycerine to alcohol exceeds 1 to 6 by weight.

V. The presence of cane sugar is ascertained by a determination of sugar (by Soxhlet's or Knapp's method), before and after inversion.

BEER.

A.—METHODS OF INVESTIGATION.

By beer is to be understood a fermented and still fermenting drink, made from barley (or wheat) malt, hops, and water, and which was fermented by yeast.

I. *Determination of specific gravity.*—For this as well as all other determinations the beer is freed from carbonic acid, as far as possible, by half-filling bottles with it and shaking vigorously. It is then filtered. The specific gravity is then determined either by Westphal's balance or by a picnometer at 15° C.

II. *Determination of extract.*—Seventy-five cubic centimeters of beer are carefully weighed and evaporated in a suitable vessel to 25 cubic centimeters, care being taken to prevent boiling. After cooling water is added until the original weight is reached, and the specific gravity of the liquid taken as in I. The per cent. of extract is obtained from this specific gravity by the use of a table constructed by Dr. Schultz, and is given as "per cent. extract, Schultz."¹

III. Alcohol is determined by distilling the beer. A picnometer of about 50 cubic centimeters capacity and with a graduated neck is used as a receiver. The picnometer is carefully calibrated. Seventy-five cubic centimeters of beer are distilled until the distillate reaches about the center of the scale on the neck of the picnometer. This is then cooled to 15° C., dried, and weighed, and the alcohol determined by means of Baumber's table.

$$A = \frac{D \cdot d}{g}$$

The percentage of alcohol by weight is to be given. In very acid beers it is necessary to neutralize before distilling.

IV. *Original gravity of wort.*—This may be ascertained, approximately, by doubling the per cent. by weight of alcohol found as above and adding the per cent. of extract. As this procedure is not exact, it may be made more nearly so by using the formula

$$\frac{100(E + 2.0665 A)}{100 + 1.0665 A}$$

V. Degree of fermentation. This is estimated by using the formula

$$V_1 = 100 \left(1 - \frac{E}{c} \right)$$

VI. *Sugar determination.*—This is to be determined directly, in the beer previously freed from carbonic acid, by Soxhlet's method of weighing the reduced copper; 1.13 parts of copper correspond to 1 part anhydrous maltose.

VII. Determination of dextrin is seldom required, and if required is to be performed by Sachsse's method.

VIII. *Nitrogen.*—Twenty to thirty cubic centimeters are evaporated in a Hofmeister "schälchen" or on warm mercury, and the extract burned with soda-lime. The nitrogen may also be determined by Kjeldahl's method.

IX. *Acids.*—(a) Total acids: The carbonic acid is driven off from 100 cubic centimeters of beer by heating in beakers for a short time to 40° C., and the beer then titrated with baryta water (one-fifth to one-tenth normal). The saturation point is reached when a drop of the liquid has no longer any action on litmus paper. The acidity is to be given in cubic centimeters normal alkali required for 100 grams beer and as

¹Hilger, p. 123.

grams per cent. of lactic acid. The indication "acidity" or "degree of acidity" is insufficient.

(b) Normal beer contains but a very small quantity of acetic acid. The determination of fixed acid in the repeatedly evaporated extract is to be cast aside. The acetic acid produced by souring of the beer is shown by the increase in total acids. A qualitative test of the presence of acetic acid in the distillate from beers containing acetic acid is sufficient. Neutralized beer is to be acidified with phosphoric acid and distilled. Weigert's method is recommended.

X. *Ash*.—Thirty to fifty cubic centimeters of beer are evaporated in a large tarred platinum dish and the extract carefully burned. If the burning takes place slowly, the ash constituents do not fuse together.

XI. *Phosphoric acid*.—This is to be determined in the ash obtained by evaporating and burning in a muffle 50 to 100 cubic centimeters of beer to which not too much baric hydrate has been added. The phosphoric acid is determined in the nitric acid solution of the ash by the molybdenum method.

XII. *Sulphuric acid*.—The direct determination is not permissible. The determination is to be made by using the ash prepared by burning with sodic hydrate and potassium nitrate or baric hydrate and proceeding in the ordinary way.

XIII. *Chlorine*.—This is to be determined in the ash prepared with sodic hydrate.

XIV. *Glycerine*.—Three grams calcic hydrate are added to 50 cubic centimeters of beer, evaporated to a sirupy consistence, about 10 grams coarse sea-sand or marble added and dried. The dry mass is rubbed up, put into a capsule of filter paper, placed in an extraction apparatus, and extracted for six to eight hours with 50 cubic centimeters alcohol. To the light-colored extract at least an equal volume of ether is added, and the solution, after standing awhile, poured into or filtered into a weighed capsule. After evaporating the alcohol and ether, the residue is heated in a drying oven at 100° to 105° C. to a constant loss of weight. In beers rich in extract the ash contained in the glycerine can be weighed and subtracted. In case the glycerine contains sugar this can be determined by Soxhlet's method and subtracted.

XV. Hop substitutes are to be determined by Dragendorff's method. Picric acid is to be determined by Fleck's method. In examining for alkaloids, check experiments with pure beer must in all cases be made.

XVI. *Sulphites*.—One hundred cubic centimeters of beer are distilled after the addition of phosphoric acid and the distillate conducted into iodine solution. After one-third has distilled over, the iodine-colored distillate is acidified with hydrochloric acid and baric chloride added. If sulphites were not contained in the beer no precipitate is observed, but at the utmost a turbidity.

XVII. *Salicylic acid*.—This may be shown qualitatively by shaking with ether, chloroform, or benzene. The solution is allowed to evaporate, the residue dissolved in water, and a very dilute solution of ferric chloride added. The addition of too much acid and too violent shaking is to be avoided. The smallest trace of salicylic acid may also be shown by dialysis, as it passes very readily through membrane.

NOTE.—All the results of an investigation are to be stated in percentages by weight.

B.—METHODS OF JUDGING PURITY OF BEERS.

I. It is unjust to demand in a fermented beer an exact ratio of alcohol to extract, as the brewer can not regulate the degree of fermentation within narrow limits. As a rule, Bavarian draught and lager beers contain from 1.5 to 2 parts of extract for each part of alcohol, but a smaller proportion of extract would not necessarily prove the addition of alcohol or glucose (the former to the beer, the latter to the wort).

II. The degree of fermentation of a beer must be such that at least 48 per cent. of the original extract has undergone fermentation.

III. If glucose or other bodies poor in nitrogen have been used in appreciable quantity as substitutes for malt, the nitrogen contents of the beer extract will fall below 0.65 per cent.

IV. The acidity of a beer should not be greater than 3 cubic centimeters normal alkali to 100 cubic centimeters beer. Acidity of less than 1.2 cubic centimeters normal alkali to 100 cubic centimeters beer indicates previous neutralization. If the acids are composed principally of lactic acid a larger quantity may be present.

V. The ash of normal beer is not above 0.3 gram to 100 grams beer.

VI. The amounts of phosphoric and sulphuric acids and chlorine in beer extract vary within such wide limits, that their determination signifies nothing as to the purity of the beer.

VII. The amount of glycerine in pure beer is not greater than 0.25 gram to 100 grams beer.

VIII. The following methods of clarifying beer are legal: (a) Filtration. (b) Well-boiled hazel or beech shavings. (c) Isinglass.

IX. The following methods of preserving beer are legal: (a) Carbonic acid. (b) Pasteurizing. (c) Salicylic acid; this only for beers intended for export to countries where the use of salicylic acid is not forbidden by law.

NOTE.—The preceding methods are also to be used in the examination of imported beer.

C.—ADMINISTRATIVE NOTE.

It is absolutely necessary that the beer be preserved in well-corked green-glass bottles. Stone jugs and such vessels are not to be used.

The beer samples are to be protected from light and kept at a low temperature.

Care in making tests is, above all, necessary.

**OFFICERS AND REPORTERS OF THE ASSOCIATION OF OFFICIAL
AGRICULTURAL CHEMISTS OF THE UNITED STATES
FOR 1887-1888.**

PRESIDENT,

Prof. JOHN A. MYERS, Director of the West Virginia Agricultural Experiment Station

VICE-PRESIDENT,

Prof. M. A. SCOVELL, Director of the Kentucky Agricultural Experiment Station.

SECRETARY,

CLIFFORD RICHARDSON, Chemist to the District of Columbia and Honorary Assistant
Chemist United States Department of Agriculture.

EXECUTIVE COMMITTEE.

Dr. H. W. WILEY, of Washington.

Dr. WILLIAM FEAR, of Pennsylvania.

REPORTERS.

Phosphoric acid.—Dr. Richard H. Gaines,
of Richmond, Va.

Potash.—Dr. E. H. Jenkins, of New
Haven, Conn.

Nitrogen.—Prof. M. A. Scovell, of Lex-
ington, Ky.

Cattle foods.—Prof. G. C. Caldwell, of
Ithica, N. Y.

Dairy products.—Dr. H. W. Wiley, of
Washington, D. C.

Fermented liquors.—Prof. W. B. Rising,
of Berkeley, Cal.

Sugar.—Prof. W. C. Stubbs, of Kenner,
La.

CONSTITUTION OF THE ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS.

(1) This association shall be known as the Association of Official Agricultural Chemists in the United States. The objects shall be (1) to secure uniformity and accuracy in the methods, results, and modes of statements of analysis of fertilizers, soils, cattle foods, dairy products, and other materials connected with agricultural industry; (2) to afford opportunity for the discussion of matters of interest to agricultural chemists.

(2) Analytical chemists connected with the United States Department of Agriculture, or with any State or national agricultural experiment station or agricultural college, or with any State or national institution or body charged with official control of the materials named in section 1, shall alone be eligible to membership, and one such representative for each of these institutions or boards, when properly accredited, shall be entitled to a vote in the association. Only such chemists as are connected with institutions exercising official fertilizer control shall vote on questions involving methods of analyzing fertilizers. Any person eligible to membership may become a member at any meeting of the association by presenting proper credentials and signing this constitution. All members of the association who lose their right to such membership by retiring from positions indicated as requisite for membership shall be entitled to become honorary members and to all privileges of membership save the right to hold office and vote. All analytical chemists and others interested in the objects of the association may attend its meetings and take part in its discussions, but shall have no vote in the association.

(3) The officers of the association shall consist of a president, vice-president, and secretary, who shall also officiate as treasurer; and these officers, together with two other members to be elected by the association, shall constitute the executive committee. When any officer ceases to be a member by reason of withdrawing from a department or board whose members are eligible to membership, his office shall be considered vacant, and a successor may be appointed by the executive committee to continue in office till the annual meeting next following.

(4) There shall be appointed by the president, at the regular annual meeting, a reporter for each of the subjects to be considered by the association.

It shall be the duty of these reporters to prepare and distribute samples and standard reagents to members of the association and others desiring the same; to furnish blanks for tabulating analyses, and to present at the annual meeting the results of work done, discussion thereof, and recommendations of methods to be followed.

(5) The special duties of the officers of the association shall be further defined, when necessary, by the executive committee.

(6) The annual meeting of this association shall be held at such place as shall be decided by the association, and at such time as shall be decided by the executive committee, and announced at least three months before the time of meeting.

(7) Special meetings shall be called by the executive committee when in its judgment it shall be necessary, or on the written request of five members; and at any meeting, regular or special, seven enrolled members entitled to vote shall constitute a quorum for the transaction of business.

(8) The executive committee shall confer with the official boards represented with reference to the payment of expenses connected with the meetings and publication of the proceedings of the association.

(9) All proposed alterations or amendments to this constitution shall be referred to a select committee of three at a regular meeting, and after report from such committee may be adopted by a vote of two-thirds of the members present and entitled to vote.

BOUND

JUN 7 1917

**UNIV. OF MICH.
LIBRARY**



